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THE INTERACTIONS BETWEEN CATTLE AND CALIFORNIA BIGHORN SHEEP ON THE ASHNOLA MOUNTAIN RANGE

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EXECUTIVE SUMMARY

Historical impacts of cattle and bighorn sheep grazing on the Ashnola grasslands were difficult to identify because of small sample sizes, and experimental confounding due to variable grazing pressure, time of sampling, sampling technique and sampling locations. For example, total foliar cover on Crater and Flatiron Mountains declined significantly both inside and outside grazing exclosures between 1960 and 1967, indicating response not only to grazing pressure, but also to the influence of variable annual weather patterns. Moreover, botanical changes on Flatiron Mountain between 1967 and 1972 provided inconsistent conclusions, as climax and seral plant species both displayed increases, decreases, and/or relative stability in foliar cover among different sampling sites. Nonetheless, forage availability apparently increased on Flatiron Mountain between 1960 and 1972, particularly following removal of cattle in 1968.

Recent field inspections indicate that satisfactory foliar cover, including that of climax plant species, currently exists throughout most of Crater and Flatiron Mountains. Present cattle management activities are superior to those prior to 1968, and do not pose significant threats to the continued welfare of bighorn sheep in the Ashnola, particularly since livestock use is concentrated on Crater Mountain while bighorn sheep use is concentrated on Flatiron Mountain. Although bighorn sheep and cattle generally depend upon similar forage species, differing preference for terrain and specific plant species reduces potential competition between these two ungulates. Behavioral aversion between bighorn and cattle has been reported elsewhere, although no evidence exists to indicate that the Ashnola bighorn are excluded from ranges occupied by cattle. Potential behavioral interference with the bighorn fall rut on Flatiron Mountain is likely mitigated by the exclusion of livestock from South Slope, plus the annual departure of cattle from Juniper Slope by July 15. Transmission of disease between cattle and California bighorn sheep in the Ashnola appears negligible.

The potential benefits of utilizing livestock grazing to improve bighorn sheep winter habitat are theoretically likely, but have not been verified on a management unit basis. Improvement in the quality and quantity of fall forage for bighorn sheep is likely insignificant under the existing livestock grazing regime, as cattle are completely excluded from South Slope, while Juniper Slope is utilized by cattle too late in the season for substantial regrowth to take place. Although cattle grazing may improve forage availability to bighorn sheep by reduction in old growth on large forage plants such as bluebunch wheatgrass, current cattle stocking rates are moderate, and will not likely initiate succession toward more seral plant communities, some of which may be more preferred by bighorn sheep.

The diet of bighorn sheep in the Ashnola consists primarily of grasses throughout the year, although some forbs and pasture sage display high forage preference indices during spring and early winter respectively. No evidence exists to suggest that there is any mortality due to toxic plants.

On Flatiron Mountain, South Slope represents the most important winter-spring range. Lesser used winter-spring ranges include Juniper, Starvation, and Flatiron Slopes.

Optimal California bighorn sheep habitat includes a) escape terrain for lamb/ewe groups adjacent to spring ranges, and b) a variety of forages including grasses, forbs and woody plants, all of which contribute to diet and forage preferences during different and specific portions of the grazing year. In the Ashnola, optimal bighorn sheep habitat is characterized best by a vegetational mosaic of climax and seral plant communities available primarily within steppe bunchgrass vegetation. Habitat and forage preferences of mule deer differ markedly from those of bighorn sheep, and likely have relatively minor impact on grassland production and forage availability to bighorn sheep.

California bighorn sheep numbers in the Ashnola declined rapidly between 1880 and 1909, and remained low in 1950. Populations generally increased between 1960 and 1967, but declined slightly thereafter. Because census techniques have not been standardized for all years of survey, population counts between years are not directly comparable. Consequently, there is no definitive evidence to indicate that the Ashnola bighorn is either stable or declining, although it appears unlikely that population growth is taking place.

Lamb/ewe ratios on South Slope ranged from 0.42 to 0.69 between 1960 and 1967, but averaged only 0.25 between 1970 and 1983. This value does not seem substantially lower than lamb/ewe ratios for the Vaseaux Lake population of bighorn, which averaged 0.29 between 1971 and 1980. However, actual differences between the two ratios may be somewhat higher, as censusing was conducted primarily in spring and summer in the Ashnola, but not until late winter in the Vaseaux Lake area. Lamb/ewe ratios in the late 1960's and early 1970's were more than 10% higher for the Chilcotin River bighorn than for the Ashnola bighorn.

Inclement weather, parasites, conception rates, diseases and hunting likely do not limit recruitment rates of bighorn sheep in the Ashnola at present. Although lamb/ewe ratios increased to 0.47 in 1978 following winter feeding, confounding of management effects was produced by coincidentally mild winters, mineral supplements, and provision of antihelminthic drugs. Following 1978, lamb/ewe ratios declined to 0.24 by 1983 despite continued winter feeding. Strong circumstantial evidence suggests that lamb/ewe ratios are currently depressed by coyote predation of lambs.

Optimal numbers of cattle and California bighorn sheep can be determined best with new information regarding forage availability within management units and/or habitats during specific periods of use by each ungulate species. Future research should a) document the degree of coyote predation of lambs, b) quantify current seasonal distribution and numbers of California bighorn sheep in the Ashnola, and c) assess the impacts of current cattle management rotations on forage production, forage quality, forage availability, plant vigor and livestock weight gains. All changes in management activities should be monitored carefully so that the degree of success or failure can be determined quantitatively. Such monitoring is required to further refine and improve managerial skills and goals. South Slope should continue to be reserved for exclusive use by California bighorn sheep.

INTRODUCTION

This investigation was initiated by the Agriculture and Rural Development Subsidiary Agreement (ARDSA) Management Committee following a conflict of interests among resource participants in the Crater Mountain-Juniper Creek Coordinated Resource Management Plan (CRMP). The Crater Mountain-Juniper Creek Management Unit, commonly referred to as the Ashnola, supports 300 to 400 California bighorn sheep which are identified in the CRMP as the primary resource user. Livestock grazing constitutes an important, albeit secondary resource use, with the Keremeos Stock Breeders Association holding grazing licenses north of the Ashnola River on Crater Mountain. Grazing licenses south of the Ashnola River on Flatiron Mountain are held by the Lower Similkameen Indian Band.

In 1980, the Keremeos Stock Breeders Association submitted a request to the Ministry of Forests (MOF) to increase by 30% the 1,188 AUMs of livestock grazing then in existence on Crater Mountain. Range agrologists representing the Ministry of Forests believed that improved range management and capital improvements in the Ashnola had produced a full recovery of previously overgrazed ranges, and argued that sufficient forage existed to warrant such an increase. Moreover, the Ministry of Forests maintained that AUMs could be increased without detrimental impacts on the California bighorn sheep.

The requested increase in AUMs was initially rejected by the Fish and Wildlife Branch of the B.C. Ministry of Environment, which maintained that the full impact of cattle grazing on California bighorn sheep remained unknown. A subsequent revised request for a 20% increase in AUMs was also opposed by the B.C. Fish & Wildlife Branch for the same reason. To resolve these conflicts regarding appropriate allocation of AUMs of cattle grazing, a series of discussions occurred between the Ministries of Environment and Forests, which concluded on August 13, 1981 with the following recommendations:

1. By the fall of 1981, the Ministry of Forests was to provide information regarding diets of domestic livestock in the Southern Interior of British Columbia, with particular emphasis on the Crater Mountain Area.
2. By the fall of 1981, the Ministry of Forests was to establish transects at locations determined in cooperation with the Fish & Wildlife Branch. Such transects were to provide data regarding trends in botanical composition and frequency of occurrence.
3. The Fish & Wildlife Branch was to initiate immediately an assessment of lamb/ewe ratios, plus degree of utilization of the Ashnola by California bighorn sheep.
4. AUMs on Crater Mountain would be increased by 20% pending completion of recommendations 1 and 2 above. Such an increase would be terminated if a Problem Analysis indicated that the increase is, or will be detrimental to the sheep population.
5. The Ministry of Forests and the Fish & Wildlife Branch would request the Regional Resource Management Committee to initiate a Problem Analysis which would assess potential detrimental impacts of cattle grazing on California bighorn sheep in the Ashnola.

In response to this request for a problem analysis, a Research Steering Committee was convened in 1982 with representatives from the Ministries of Agriculture and Food (Mr. Alf Bawtree), Environment (Mr. Bob Lincoln), and Forests (Mr. Phil van Mol). This committee formulated the initial goals for this Problem Analysis, which is jointly financed by Agriculture Canada and the Ministry of Agriculture and Food of British Columbia under the ARDSA agreement. Additional financial support has been contributed by the B.C. Ministries of Environment (Fish and Wildlife Branch) and Forests (Range Management Branch).

Substantial research directed at ecological relationships in the Ashnola has already been conducted by Fish and Wildlife Branch personnel and by graduate students at the University of British Columbia and Simon Fraser University. Unfortunately, the long term welfare of the sheep population, including interspecific relationships among sheep, cattle and mule deer, still remain ambiguous.

Such ambiguity persists for three primary reasons:

1. Much of the previous research utilized alternative sampling techniques and experimental approaches, which often occurred on different research sites emphasizing variable research objectives. Synthesis of existing research information is therefore difficult.
2. Previous management activities have vacillated in response to the objectives and opportunities of individual resource managers. Examples include a) variable stocking rates, b) exclusion of cattle followed by

selective reintroduction, c) exclusion of hunting followed by limited hunting, d) prescribed burning, e) predator control, f) mineral supplements, g) antihelminthic drugs, and h) winter feeding of sheep.

3. These alternative research and managment activities have often occurred simultaneously, precluding the opportunity for direct, unconfounded assessment of the success of each management alternative.

Perhaps because of these three factors, much of the information pertaining to the Ashnola remains unsynthesized. The current Problem Analysis will investigate this existing information in order to define past and present interactions between wildlife and livestock in the Ashnola, and to identify research programs necessary to develop future management alternatives.

OBJECTIVES OF THE PROBLEM ANALYSIS

The overall objective of the Problem Analysis is to maximize combined benefits for California bighorn sheep and cattle in the Ashnola by clarifying information required to achieve this maximization. Towards this objective, the following specific questions have been identified by the Ashnola Research Committee (Appendix A) as Terms of Reference.

1. What is the extent of behavioral exclusion of California bighorn sheep from ranges occupied by cattle?
2. Do livestock management techniques have detrimental effects on California bighorn sheep?
3. Do cattle improve forage values for California bighorn sheep?
    a. By what processes does this forage improvement occur?
    b. What are the short and long term ecological implications of using cattle to improve forage for California bighorn sheep?
4. Are diseases and parasites transmitted between cattle and California bighorn sheep that may be injurious to sheep?
5. What are the ecological impacts of mule deer on the grasslands of the Ashnola region?
6. What is the current ecological status of the Ashnola grasslands?
7. What effects have cattle and California bighorn sheep had on the Ashnola grasslands?
8. What are the optimal range conditions for California bighorn sheep?
9. What is the seasonal distribution of California bighorn sheep in the Ashnola?
10. What are the critical lambing areas in the Ashnola?

11. Are lamb/ewe ratios in the Ashnola lower than in other populations of California bighorn sheep?
    a. What factors contribute to these low lamb/ewe ratios?
    b. What are the long term implications of low lamb/ewe ratios for population growth of California bighorn sheep in the Ashnola Region?
12. What are the feeding patterns of California bighorn sheep in the Ashnola?
    a. Are toxic plants a problem for California bighorn sheep in the Ashnola?

METHODS

In order to address the Terms of Reference, this Problem Analysis presents a comprehensive, critical review of existing literature and information pertaining to the Ashnola. Additionally, a series of interviews with resource management personnel (Appendix B) was conducted to provide a synopsis of perceptions and concerns of key participants in the Ashnola controversy. An initial list of interviewees provided by the Ashnola Research Committee was later expanded to include as many people as possible within the Ministries of Agriculture and Food, Environment, and Forests. Ranchers were also interviewed to obtain input from private resource users. During all interviews, individuals were asked specific questions, as well as given opportunity to expound on their perspectives of the history, current situation, plus future research and management needs of the Ashnola region.

DESCRIPTION AND LOCATION OF THE ASHNOLA REGION

The Ashnola region lies immediately north of the 49th parallel in south-central British Columbia, with the California bighorn sheep management area including approximately 14,175 ha (35,000 acres) (Morrison 1972). Physiographically, the Ashnola occurs within the mountainous southern portion of the Interior Plateau (Brink and Farstad 1949), as part of the transition zone between the Cascade Mountains to the west, south and east, and the Interior Plateau to the north (Holland 1964). Climatologically, the Ashnola is characterized by the rain shadow effect of the Cascade Mountians, with two seasonal maxima of precipitation (Tisdale and McLean 1957). Elevation varies considerably, with a small portion of the area lying below 600 m (2000 feet) in deeply trenched, U-shaped valleys, while uplands of moderate relief rise to 1500 m (5000 feet) (Harper 1969).

The entire region was glaciated during the Pleistocene, with subsequent soils derived primarily from glacial material. Chernozems support open and semi-open grasslands, while brunisols underlay forested areas (Harper 1969).

Grasslands occur throughout the elevational range of the Ashnola, occasionally extending up to alpine tundra. Below 600 m (2000 feet), a parkland of open ponderosa pine and scattered Douglas-fir intermixes with open grasslands dominated by bluebunch wheatgrass. With increasing elevation between 600 and 1400 m (2000 and 4500 feet), Idaho fescue assumes co-dominance with bluebunch wheatgrass in open areas. On wetter sites above 600 m (2000 feet), montane forest dominated by Douglas-fir produces an understory composed principally of pinegrass. The Douglas-fir zone merges with Engelmann spruce between 1500 and 1800 m (5000 and 6000 feet), depending upon aspect and slope (Harper 1969).

HISTORY OF THE ASHNOLA REGION

Domestic livestock were first introduced into the Ashnola in the late 1880's when stockmen spread south from the Okanagan and Similkameen Valleys (Vrooman 1941). Livestock use was extremely heavy, such that severe overutilization of bighorn sheep winter range was apparent within 20 years (Blood 1961). In 1912, the Game Department expressed concern over severe retrogression of bighorn sheep winter range (Blood 1961). The following year, an Order-in-Council reserved South Slope for exclusive bighorn sheep use. This measure failed to improve habitat for bighorn sheep however, as livestock grazing remained excessive in the Ashnola until 1950, occasionaly serving as year-round pasture for up to 250 horses, while providing annual forage for as many as 1000 domestic sheep and 600 cattle (H.T. Tweddle, pers. comm., In: Demarchi 1965). South Slope continued to suppport domestic livestock grazing, and was utilized as a fall holding pasture for cattle until 1968.

In 1968, the B.C. Fish and Wildlife Branch purchased 243 ha (600 acres) of private range on Crater Mountain, and successfully closed Crown ranges on Crater and Flatiron Mountains to livestock grazing "for as long as and to the extent deemed necessary for the welfare of the Ashnola band of California bighorn sheep" (1968 Agreement of the Ministers of Forests and Recreation & Conservation). Cattle were not reintroduced into the Ashnola until 1977, when requests from the Keremeos Stock Breeder's Association led to development of a CRMP for this region.

Stocking rates on Crater Mountain equalled 1,250 AUMs in 1977, but declined to 1,188 in 1978 following formulation of a 5 year grazing plan.

This grazing plan was subsequently altered to allow an increase of 237 AUMs in 1982, for a 1983 total of 1,425 AUMs. Livestock grazing on Flatiron Mountain, allocated to the Lower Similkameen Indian Band, equalled 350 AUMs in 1977, 425 AUMs in 1978, and reached its current level of 475 AUMs in 1979. The combined stocking rates in the Ashnola, including both Crater and Flatiron Mountains, therefore totaled 1,900 Animal Unit Months in 1983.

In addition to livestock grazing, other activities have also influenced California bighorn sheep in the Ashnola region. Prior to historical competition between sheep and livestock, indiscriminate hunting by the initial settlers produced precipitous declines in the bighorn sheep population by the 1890's (Williams 1925). Hunting was discontinued in 1909, and with the exception of 1947, remained closed until 1954 when a rams only hunting policy was reintroduced (Sugden 1961, Archibald 1982). Limited entry ram hunting replaced the open ram season in 1974, and currently remains in effect (Ramsay 1980).

In addition to control of livestock and hunting, wildlife management personnel have employed other techniques to enhance sheep populations in the Ashnola. Between 1940 and 1970, game warden Adam Monks (pers. comm., In: Blood 1961) hunted and killed approximately 70 cougars and 40 bobcats to reduce predation on California bighorn sheep. Similarly, 12 poison baits were scattered in 1951 and 1957 (A. West pers. comm., In: Blood 1961) to reduce the presence of coyotes. Predator control was again attempted in 1973, when 2 bobcats, 2 coyotes, 2 bears, 3 cougars and 4 lynx were trapped or shot (B. Webster unpub., In: Harper 1984). In addition, track evidence indicated that between 35 and 40 poison baits were ingested primarily by coyotes. Habitat improvement programs have included three spring burns and one fall burn between 1976 and 1980, while a supplemental winter feeding program providing commercial sheep pellets, mineral mix, and antihelminthic drugs was initiated in 1977.

CURRENT MANAGEMENT ACTIVITIES IN THE ASHNOLA REGION

A variety of management activities are being conducted on the Ashnola grasslands to improve productivity of the California bighorn sheep herd. Winter feeding programs began during 1977 and periodically included pelleted, commercial sheep mixes and/or alfalfa hay. These winter feeding activities have been conducted by the Fish & Wildlife Branch as well as local sportsmen's groups. Currently, winter feed is placed onto the grasslands in early or late fall, and made freely available for sheep consumption depending upon timing and severity of winter conditions. Winter feeds occasionally include granular mineral supplements.

Mineral supplements during other times of the year have also been provided to the sheep in the form of salt blocks or alfalfa mixed with molasses. Fertilization of grasslands to improve forage quality has occurred periodically on an ad hoc basis, although no formal fertilization program currently exists. Similarly, antihelminthic drugs are sporadically provided to reduce the infestation of lung worm populations.

Prescribed Burning

Harcombe and Kowall (1982) investigated fire ecology of the Ashnola region, and concluded that 6 major fires have occurred since 1840. Although Harcombe and Kowall (1982) found no evidence that current grasslands were forested at one time, they concluded that grasslands could expand into forested areas if fires occurred during extended periods of drought, which would make tree reestablishment difficult or impossible. Once a grass cover became established, competiton for available moisture could permanently shift the vegetative balance from trees to an herbaceous cover.

For such reasons, prescribed burning has become an increasingly popular management tool for improving California bighorn sheep habitat. These improvements are postulated to occur not only because of grassland expansion into forested areas, but also because of reduced tree encroachment into existing grassland cover. Harcombe and Kowall (1982) recommended the following criteria for selection of sites to be burned for the purpose of grassland promotion:

1) South to west aspects.
2) Forested areas with Brunisolic soil development.
3) Absence of topographical shading from higher terrain to the south and west.
4) Morainal and colluvial soils without a high rubbly talus component.
5) Slopes which do not exceed 45%.
6) Elevations which do not exceed 1950 m (6400 feet).

Recent fires in the Ashnola include both prescribed and accidental burns. A fall burn was prescribed in the Joe Basin during 1980 to remove mountain big sagebrush. A spring burn of unknown origin occurred on Crater

Mountain near Hargreaves Pasture in 1981, while South Slope burned accidentally in the fall of 1981 following escape of a fire prescribed near the base of the slope. Future prescribed burns are scheduled for forested areas adjacent to South Slope.

Livestock Grazing

There are currently 1900 AUMs of livestock grazing within the Crater Mountain-Juniper Creek Management Unit, 1,425 of which are allocated to the Keremeos Stock Breeders Association on Crater Mountain, and 475 of which are allocated to the Lower Similkameen Indian Band on Flatiron Mountain. On Crater Mountain, the grazing season extends from May 15 to October 31, and includes 120 cows plus 180 yearlings. The grazing season is slightly earlier on Flatiron Mountain, extending from May 7 to September 30. Animal Unit Months on Flatiron Mountain consist entirely of cows, which total 100.

The grazing system on Crater Mountain is based on a 2 year rest-rotation plan, which alternates use of spring ranges, but maintains fixed grazing schedules for the summer and fall ranges. A rest-rotation system is not employed on Flatiron Mountain, as cattle exclusion from South Slope limits grazing options. Grazing schedules for Crater and Flatiron Mountain are summarized in Appendix C.

CURRENT OBJECTIVES AND PERCEPTIONS OF THE ASHNOLA RESOURCE USERS

Livestock Graziers

Ranchers holding grazing permits on the Crater Mountain-Juniper Creek Management Unit are generally pleased with the current Coordinated Resource Management Plans. They support the open communication fostered by coordinated resource management planning, and express satisfaction with current stocking rates. An immediate increase in AUMs is deemed inappropriate from two perspectives: (1) Increased riding requirements may negate any benefit from increased AUMs, and (2) The value of additional AUMs would not likely offset the anticipated difficulties in gaining approval for such an increase.

Existing stocking rates are not believed to be detrimental to the bighorn sheep population. Livestock graziers emphasize that current range conditions are excellent, and that cattle grazing may even benefit bighorn sheep by preventing the accumulation of standing dead foliage, thereby improving the accessibility to new growth in bunchgrasses. Indeed, ranchers question the value of the rest rotation grazing system practiced on Crater Mountain, proposing instead an annual grazing system which would utilize all pastures each year. This annual use would prevent forage from becoming coarse and unavailable during the year of rest, and would also reduce the current logistical difficulties associated with alternating cattle rotations.

Cattle interference with the bighorn sheep during rut is considered unlikely as the two animal species are observed to graze in close proximity. Moreover, dogs are no longer utilized during cattle round-up, further minimizing disturbance of California bighorn sheep by ranching activities. Stockmen consider the exclusion of cattle from South Slope to be regrettable because of restricted grazing options for livestock on Flatiron Mountain.

In addition to interactions between bighorn sheep and cattle, livestock graziers are also concerned with other resource impacts in the Ashnola, including forest encroachment on Crater Mountain, proposed access routes for logging, irregular weekend opening dates for the hunting season, plus insufficient notification of logging plans.

British Columbia Ministry of Forests

Agrologists of the B.C. Ministry of Forests believe that an increase in AUMs is feasible, and maintain that forage currently available in the Crater Mountain-Juniper Creek Management Unit is being underutilized. The Ministry of Forests emphasizes the importance of good grazing management in promoting positive interactions between sheep and cattle. Undesirable competition between these two animal species is considered avoidable if sufficient time is allowed for regrowth of forage following cattle grazing. A primary cattle management objective is to utilize each forage plant annually, at an appropriate phenological stage, thereby improving forage for California bighorn sheep in two ways: (1) Increased accessibility of new growth by removal of old growth, and (2) Encouragement of successionally induced, forb-rich, seral plant communities believed to be preferred by sheep.

The Ministry of Forests considers the exclusion of cattle from South Slope to be undesirable, as grazing options for livestock on Flatiron Mountain become unnecessarily restricted. Similarly, the inflexible October 15 livestock removal date requested by the Fish and Wildlife Branch is also believed to impose undesirable restrictions. Such inflexibility of removal dates reduces the opportunity for developing grazing plans based upon proper utilization criteria, and also imposes logistical difficulties on ranchers, who typically lack alternative ranges on which to pasture cattle.

British Columbia Fish & Wildlife

An increase in livestock AUMs in the Ashnola is opposed by wildlife management personnel, as the impacts of cattle grazing on bighorn sheep populations remain unclear. The Fish & Wildlife Branch emphasizes that California bighorn sheep have been designated as the primary resource user of the Crater Mountain-Juniper Creek Management Unit, and therefore seeks to increase sheep numbers to as many as 1,000 animals. To promote this level of sheep numbers, Fish & Wildlife personnel argue that increased livestock grazing should not occur unless it can be demonstrated that cattle grazing is beneficial for bighorn sheep.

The Fish & Wildlife Branch recognizes that cattle grazing may benefit California bighorn sheep by (1) preventing excessive accumulation of dead foliage in bunchgrasses, (2) improving forage quality through reversal of plant phenology to an earlier stage, and (3) establishing and maintaining a forb-rich seral community possibly preferred by sheep. Wildlife management personnel also point out however, that interactions between wildlife and livestock extend beyond biological relationships expressed through the forage resource. Such sheep/cattle interactions embrace political, logistical, behavioral and social considerations, any of which may be undesirable for bighorn sheep. For example, cattle remaining in Hargreaves pasture beyond October 15 may interfere severely with the sheep rut which begins in late October.

The Fish & Wildlife Branch believes that Animal Unit Months of livestock grazing must not increase until future research identifies optimal ratios and densities of bighorn sheep and cattle relative to management objectives. This future research must clearly document appropriate criteria by which the positive and negative impacts of cattle grazing on California bighorn sheep can be evaluated.

Summary of Resource Conflicts

All resource users agree that welfare of the California bighorn sheep population constitutes the primary management objective. Both the ranching community and the B.C. Ministry of Forests range management staff believe that current cattle grazing activities are not affecting the sheep herds deleteriously. Moreover, these two resource groups contend that cattle grazing could be expanded without detriment to the sheep herd, and may even increase forage availability for sheep and cattle.

The B.C. Ministry of Environment, Fish & Wildlife Branch, is skeptical that cattle grazing can be increased without unacceptable negative impacts on bighorn sheep. Historical overgrazing by livestock is cited as a primary reason to maintain cattle grazing at current, presumably acceptable levels. Moreover, Fish & Wildlife Branch believes that any increased grazing in the Ashnola region should be allocated to California bighorn sheep, which are mutually acknowledged as the primary resource user.

The major source of conflict among resource users concerns appropriate numbers of cattle and California bighorn sheep. Disagreements arise from differences in economic objectives, conflicting government agency policies, and uncertainty over biological constraints and opportunities for simultaneous grazing of cattle and bighorn sheep. Coordinated Resource Management Planning has facilitated communication and promoted an environment conducive to accommodation and compromise of differing resource objectives. Remaining disagreements focus primarily on the optimal, most efficient biological means of achieving multiple resource management objectives. Much of the ecological information collected in the Ashnola region addresses these biological questions. Resource users anticipate that synthesis of this ecological information within an integrated document will facilitate their respective and mutual management goals.

DESCRIPTION OF THE ASHNOLA REGION GRASSLANDS

Vegetation Types

The first detailed description of vegetation types on Flatiron Mountain was provided by Blood (1961), who described 6 communities based upon classifications proposed by Tisdale (1947) and Krajina (1959). Blood (1961) identified two lower elevation grasslands: a bluebunch wheatgrass/Sandberg's bluegrass community which occurs between 600-1200 m (2000-4000 feet), and a bluebunch wheatgrass/Idaho fescue community which occurs primarily above 1050 m (3500) feet, and occasionally merges with subalpine grasslands at 1800 m (6000 feet) on south-facing slopes.

Forested communities described by Blood (1961) include a narrow, ponderosa pine type, transitional between grasslands and the extensive Douglas-fir zone, which ranges between 450 m (1500 feet) on north-facing slopes and 1150 m (3800 feet) on warm, southerly exposed slopes. Engelmann spruce/subalpine fir replaces Douglas-fir at higher elevations, while alpine grasslands at climax are dominated by sheep fescue and alpine bluegrass.

Blood (1961) noted that many of these climax plant communities varied among topographic sites, and had been altered substantially by past disturbances such as fire and grazing. Consequently, Demarchi (1965) described 10 principal lower elevation grasslands on Flatiron Mountain, including 4 climax (bluebunch wheatgrass/junegrass; bluebunch wheatgrass/Idaho fescue; mountain big sagebrush/Idaho fescue; mountain big sagebrush/pinegrass) and 6 successional communities. Similarly, Harper (1969) and Morrison (1972) both described Kentucky bluegrass communities dominant on orthic black soils of Juniper Slope. Morrison (1972) and Brink et al. (1972) investigated alpine grasslands near Joe Lake, and identified two communities dominated by sedges and timber oatgrass/sedge respectively.

Harcombe and Kowall (1982) mapped 14 relatively homogenous vegetation landscapes of Flatiron Mountain which incorporate most of the plant communities identified by previous authors. Grasslands include Kentucky bluegrass, bluebunch wheatgrass/Idaho fescue, bluebunch wheatgrass/junegrass and mountain big sagebrush, plus sedge communities in the alpine tundra zone. Forested communities are characterized primarily by Douglas-fir, often with a pinegrass understory, plus Engelmann spruce and lodgepole pine.

Scheffler (1972) provided detailed descriptions of plant communities on Crater Mountain, based upon habitat types proposed by McLean (1969). Climax habitat types are similar to those described for Flatiron Mountain, and include big sagebrush/needleandthread, ponderosa pine/bluebunch wheatgrass, Idaho fescue/wild buckwheat, bluebunch wheatgrass/junegrass/Idaho fescue, Douglas-fir/bluebunch wheatgrass, Douglas-fir/Idaho fescue, Douglas-fir/pinegrass, subalpine fir, and an alpine tundra zone characterized by sheep fescue, alpine bluegrass, alpine timothy and sedges.

Scheffler (1972) additionally noted that grazing pressures had altered these climax communities throughout Crater Mountain. Similar to Flatiron Mountain therefore, most of the California bighorn sheep wintering ranges observed by Scheffler (1972) were covered by a mosaic of successional plant communities, which varied with elevation, slope, moisture regime and soil type, plus past and present grazing practices.

Forage Production

Estimates of forage production in the Ashnola vary considerably depending on the site, season, year and technique of sampling. For example, Harper (1969) found that forage production in bluebunch wheatgrass communities on August 9, 1967 fluctuated with moisture regime, equalling 646, 942 and 2245 kg/ha (577, 841 and 2004 lbs/acre) on xeric, mesic and hydric sites respectively. Similarly, production of Kentucky bluegrass sites yielded 1627, 1589 and 3895 kg/ha (1453, 1419 and 3478 lbs/acre) on corresponding xeric, mesic and hydric sites.

Because of historical and current grazing by domestic livestock and wildlife in the Ashnola region, assessment of potential peak forage production is difficult, but can be provided with adequate sample numbers collected either in years when grazing pressure is relatively light, or from sites protected from grazing animals. Harper's (1969) forage production data were obtained in such grazing exclosures, yet still display marked variability between years, which were presumably due to differing growing conditions. For example, peak forage production of bluebunch wheatgrass equalled 1373 kg/ha (1226 lbs/acre) in 1967 compared to 1154 kg/ha (1030 lbs/acre) in 1968 (Appendix D). Similarly, peak forage production of Kentucky bluegrass declined from 1822 to 1546 kg/ha (1627 to 1380 lbs/acre) between 1967 and 1968, while pinegrass production fell to 456 from 787 kg/ha (407 and 703 lbs/acre) during this same time period (Appendix D).

Demarchi (1973a) provided the most recent estimates of forage production in the Ashnola. Moreover, forage yields were collected in 1971 and 1972, 3-4 years following removal of cattle in 1968, and may therefore be considered as suggestive of peak production potentials. Demarchi's (1973a) estimates indicate the following average dry matter production in 1972: bluebunch wheatgrass/Idaho fescue: 1539 kg/ha (1374 lbs/acre); bluebunch wheatgrass/junegrass: 1411 kg/ha (1260 lbs/acre); pasture sage/junegrass: 681 kg/ha (608 lbs/acre); junegrass/Sandberg's bluegrass: 945 kg/ha (844 lbs/acre); Kentucky bluegrass: 2660 kg/ha (2375 lbs/acre); Kentucky bluegrass/Columbia needlegrass: 1700 kg/ha (1518 lbs/acre); Columbia needlegrass/cheatgrass: 1791 kg/ha (1599 lbs/acre). Production estimates for alpine vegetation are available only for 1968, and equalled 1380 and 1768 kg/ha (1232 and 1579 lbs/acre) for sedge and sedge/timber oatgrass communities respectively (Morrison 1972).

Some forage yields presented in Appendix D likely underestimate total annual dry matter production, as they reflect only the standing crop available at the time of sampling. Such measurements may not coincide with peaks in forage production, nor do they necessarily reflect forage production available for fall regrowth. Moreover, depending upon time of sampling, weathering losses following peak forage production may underestimate total annual forage production by as much as 30% (Morrison 1972). Morrison (1972) further reported that fall regrowth increased biomass in bluebunch wheatgrass and Sandberg's bluegrass communities by 27 and 10 percent respectively. Consequently, because of the many sources of variability in forage production, values presented in Appendix D should be considered as general guidelines rather than absolute site- or season-specific estimates of forage availability.

Forage Quality

Harper (1969) investigated crude protein availability within three grassland communities from May 31-October 20, 1967. Crude protein declined in all three plant communities during this period, and were generally less than maintenance levels by October 20. Vegetation dominated by bluebunch wheatgrass declined from 14.4 to 5.4 percent crude protein, while grassland characterized by Kentucky bluegrass decreased from 13.4 to 5.8 percent. Samples within pinegrass communities were collected initially on June 28, at which time percent crude protein equalled 12.9. Subsequent values of crude protein on October 20 averaged only 4.5%.

In all three grassland communities, most of the total annual crude protein production occurred within 4 to 6 weeks following initiation of growth, with peak production levels attained approximately between June 14 and June 28 (Harper 1969). Protein yields then remained relatively constant until July 26 when Kentucky bluegrass, bluebunch wheatgrass and pinegrass sites yielded 148, 132 and 83 kg/ha (132, 118 and 74 lbs/acre) of crude protein respectively. Available crude protein declined following this date, and equalled only 86, 49 and 25 kg/ha (77, 44 and 22 lbs/acre) respectively in each of these three grassland communities. Kentucky bluegrass provided the greatest amount of crude protein per unit area at all sample dates, with bluebunch wheatgrass intermediate to Kentucky bluegrass and pinegrass sites

(Harper 1969).

Demarchi (1965) monitored crude fat, crude protein, crude fiber, ash, nitrogen free extract, calcium and phosphorus of 8 bighorn sheep winter forage species in August, November and March during the 1963-1964 winter season. Crude protein declined during winter in all forage species, and was generally below the maintenance level of 6% at the March sampling date. Wild buckwheat, yarrow and pasture sage retained highest March crude protein values (6.0, 6.0 and 5.5 percent respectively). Crude protein in March averaged lowest for grasses, ranging from 1.9% for Columbia needlegrass to 4.3% for Sandberg's bluegrass.

Crude fiber, which correlates negatively with palatability, increased between November and March in all forages other than junegrass and yarrow. Highest crude fiber in March occurred in grasses, ranging from 35.1% in bluebunch wheatgrass to 40.2% in Columbia needlegrass. March crude fiber in yarrow, buckwheat and pasture sage equalled only 22.8, 27.2 and 27.8 percent respectively.

Grasses also displayed greater declines and lower levels of calcium and phosphorus relative to yarrow, wild buckwheat, and pasture sage. Calcium ranged from .04% in junegrass to 0.35% in bluebunch wheatgrass in March, compared to 0.35, 0.40 and 1.25 percent for pasture sage, buckwheat and yarrow respectively. The seasonal decline of phosphorus in grasses was particularly severe, with foliar concentrations equalling 0.01% in March for bluebunch wheatgrass, Idaho fescue, junegrass, Sandberg's bluegrass and Columbia needlegrass. In contrast, phosphorus content of yarrow, buckwheat and pasture sage remained at 0.04, 0.04 and 0.08% at the March sampling period respectively.

Brink et al. (1972) provided the only published data available for nutrient production of alpine grasslands. Timber oatgrass/sedge and sedge communities near Joe Lake yielded 8.7 and 7.8 percent crude protein respectively. This corresponds to 24.6 and 17.3 kg/ha (22.0 and 15.4 lbs/acre) of nitrogen respectively.

Effects of Grazing on Forage Production and Quality

Harper (1969) investigated the effects of defoliation on forage production in bluebunch wheatgrass and Kentucky bluegrass plant communities during the growing season of 1968. Grazing was simulated by clipping plots to ground level at selected dates between May 31 and July 26 inclusive. Measurable regrowth occurred in bluebunch wheatgrass communities clipped on May 31 and June 14, but not in communities clipped on June 28. Regrowth in Kentucky bluegrass communities occurred in all plots clipped on and prior to July 12. Regrowth was not apparent when clipping occurred on July 26.

Total forage production of clipped plots, including regrowth following clipping, generally did not differ from total forage production of unclipped plots when annual dry matter production was assessed on August 30. For example, total production on bluebunch wheatgrass plots clipped initally on May 31 equalled 1168 kg/ha (1043 lbs/acre), while total production on unclipped plots equalled 1125 kg/ha (1004 lbs/acre). Although no measurable regrowth occurred on plots clipped June 28, the 940 kg/ha (839 lbs/acre) of forage produced on these plots did not differ significantly from the 1125 kg/ha (1004 lbs/acre) produced on undefoliated plots. Similar results were observed on the Kentucky bluegrass plots: protected plots averaged 1601 kg/ha (1429 lbs/acre) on August 30, while plots clipped initially on May 31, June 14, June 28, July 12 and July 26 provided an annual forage production of 1329, 1583, 1526, 2001 and 1589 kg/ha (1187, 1413, 1362, 1787 and 1419 lbs/acre) respectively when initial harvest and regrowth herbage on August 30 were combined.

Although statistical comparisons of treatment means were not provided, Harper (1969) concluded that defoliation did not reduce appreciably total forage production within a single growing season. No data were provided for the influences of defoliation on subsequent forage quality.

Repeated or single defoliations can reduce forage production in subsequent years. Erickson (1969; In: Harper 1969) showed that defoliation during the last two to four weeks of the initial growing period in 1967 depressed forage production in 1968. Presumably this forage reduction resulted because the plants did not have sufficient time to replenish root reserves prior to the onset of summer dormancy. Alternatively, Scheffler (1972) observed that grazing-induced seral plant communities may be more productive than vegetation nearer to climax, as junegrass/Sandberg's bluegrass communities on Crater Mountain yielded 1397 kg/ha (1247 lbs/acre), compared to only 679 kg/ha (606 lbs/acre) for a bluebunch wheatgrass/pasture sage community on South Slope.

Harper (1969) concluded that livestock grazing prior to 1967 did not appreciably reduce root reserves, as none of the plots clipped in 1968 displayed reduced forage production relative to protected plots.

Nonetheless, removal of cattle grazing after 1968 apparently promoted an increase in forage production on Flatiron Mountain (Appendix D). Forage production values for October 1960 were collected by Blood (1961) within exclosures established in May and June of 1960. Demarchi's (1965) production estimates were obtained prior to grazing use by cattle in 1963, or obtained within cages erected prior to plant growth in April of 1964. Demarchi's (1973a) values for July 1971 and 1972 were obtained from plots established as duplications of Demarchi's (1965) sample sites, and represent forage production following 3 and 4 years of rest from cattle grazing respectively.

Although direct comparisons between years are not possible because of differences between sampling dates and techniques, forage production apparently improved on Flatiron Mountain between 1960 and 1963/1964. Pasture sage/junegrass communities (Sites e and f; Appendix D) averaged 459 kg/ha (410 lbs/acre) in 1963 as compared to only 199 kg/ha (178 lbs/acre) in 1960. Similarly, vegetation dominated by bluebunch wheatgrass (Sites a, b and d; Appendix D) averaged 971 kg/ha (867 lbs/acre) in August, 1963, compared to 822 kg/ha (734 lbs/acre) in October, 1960. Columbia needlegrass communities (Site j; Appendix D) declined from 923 to 785 kg/ha (824 to 701 lbs/acre) during this same period.

These general trends of improving forage production continued following removal of cattle grazing from Flatiron Mountain in 1968. Although Kentucky bluegrass vegetation on Starvation Flats (Site i; Appendix D) produced marginally less forage in 1972 (1700 kg/ha; 1518 lbs/acre) than in 1964 (1998 kg/ha; 1784 lbs/acre), other Kentucky bluegrass sites on Starvation

Flats (Site h; Appendix D) improved dramatically from 338 kg/ha (302 lbs/acre) in 1960 to 2660 kg/ha (2375 lbs/acre) in 1972. All other plant communities also displayed improved forage production. Pasture sage/junegrass (Sites e and f; Appendix D) averaged 681 kg/ha (608 lbs/acre) in 1972, compared to 459 kg/ha (410 lbs/acre) in 1963, while junegrass/Sandberg's bluegrass (Site g; Appendix D) on Starvation Flats increased from 357 to 945 kg/ha (319 to 844 lbs/acre). Production in Columbia needlegrass (Site j; Appendix D) more than doubled from 785 to 1791 kg/ha (701 to 1599 lbs/acre), while bluebunch wheatgrass/junegrass (Site d; Appendix D) improved from 874 to 1411 kg/ha (780 to 1260 lbs/acre). Two of three bluebunch wheatgrass/Idaho fescue plant communities (Sites a, b and c) showed very large increases in forage production, with average production in 1972 equalling 1539 kg/ha (1374 lbs/acre). Production on these sites equalled only 923 hg/ha (824 lbs/acre) in 1963.

Trends in Foliar Cover

Sampling for foliar cover of grasslands has occurred throughout Flatiron Mountain with transects and/or plots established on South and Juniper Slopes (Blood 1961, Demarchi 1965, Harper 1969, Morrision 1972, Scheffler 1972, Demarchi 1973a, Harper 1983), Starvation Flats (Blood 1961, Demarchi 1965, Demarchi 1973a), Flatiron Slope, Juniper Slope (Demarchi 1965), and Relict Slope (Blood 1961, Demarchi 1965). Sampling of vegetation on Crater Mountain has been less intensive and limited to transects established near Meausette Creek (Scheffler 1972), Crater Creek (Blood 1961, Scheffler 1972) and the alpine tundra zone (Scheffler 1972). In 1981, the Ministry of Forests, in response to requests by the Ministry of Environment, established additional vegetation transects on North Crater Slope, South Crater Slope, Hargreaves Flats, Meausette Creek and West Crater Basin.

Trends in foliar cover on Flatiron and Crater Mountains are, however, difficult to assess. Similar to forage production data, numerical differences in foliar cover between years fluctuate not only in response to ungulate grazing pressure, but also in relation to differences in growing seasons, time of sampling, sampling technique, sample size and location of sampling sites. Nonetheless, those sites which have been sampled more than once between 1960 and 1984 do provide inferences regarding successional trends in plant communities. Certainly, such successional trends are related to the changes in forage production observed during this time period.

Scheffler (1972) resampled transect areas originally established by Blood (1961), and concluded that foliar cover, including that of desirable forage species, generally declined between 1960 and 1967 (Appendix E). For example, the Columbia needlegrass community (Site j, Appendix E) on South Slope identified by Blood (1961) in 1960 provided a 57% foliar cover which was dominated by Columbia needlegrass (14%), Kentucky bluegrass (11%), junegrass (8%) and bluebunch wheatgrass (6%). By 1967, Kentucky bluegrass and bluebunch wheatgrass had both declined to 2% foliar cover, while total plant cover equalled only 28%. Foliar cover of junegrass and Columbia needlegrass remained relatively unchanged at 10 and 14 percent respectively (Scheffler 1972).

Demarchi (1965) however, provided data which suggest that such apparent trends must be assessed carefully. For example, botanical information collected in 1963 near Blood's (1961) original exclosure in the plant community indicate a 92% total plant cover, with foliar cover compositions of 65% Columbia needlegrass, 13% yarrow, 12% cheatgrass and 5% bluebunch wheatgrass. Cheatgrass was not recorded by either Blood (1961) or Scheffler (1972), while yarrow was reported only by Blood (1961), at 4% foliar cover in 1960. Moreover, such dramatic fluctuations in foliar cover of Columbia needlegrass are unlikely in a 7 year period.

Demarchi (1965) stated that his cover values were collected "near" Blood's (1961) exclosure, and inferentially therefore, may not represent directly comparable replications. However, such substantially different values, collected within a localized area, indicate that botanical information, obtained from variable sampling techniques and locations, must always be interpreted cautiously, preferably with supporting data from alternative sample sites.

One such additional sample site on South Slope investigated by Blood (1961) and Scheffler (1972) also provides inconclusive evidence regarding changes in foliar cover between 1960 and 1967 (Appendix E). In 1960, Blood (1961) recorded 40% ground cover consisting primarily of bluebunch wheatgrass (11%), junegrass (10%) and Kentucky bluegrass (4%). Six years later, Scheffler (1972) reported that total cover had declined to 30%, even though bluebunch wheatgrass, considered by Demarchi (1965) to be the climax dominant on this microsite (Site d, Appendix D), remained relatively unchanged at 14%.

More consistent results regarding foliar cover changes between 1960 and 1967 are provided from two sample sites on Crater Mountain sampled by both Blood (1961) and Scheffler (1972) (Appendix F). Total foliar plant cover declined at both sample sites, from 52 and 66 percent in 1960, to only 16 and 20 percent respectively in 1967. Bluebunch wheatgrass dominated both sites in 1960, at 20 and 22 percent foliar cover, but contributed only 5 and 9 percent respectively in 1967. Similarly, junegrass declined from an average of 9.5% in 1960 to 5% in 1967. Idaho fescue, which provided 13% foliar cover on one site investigated by Blood (1961) in 1960, virtually disappeared by 1967 (Scheffler 1972).

Such vegetational changes contributed to the request by Fish and Wildlife for the removal of livestock from the Ashnola in 1968. During 1971 and 1972, Demarchi (1973a) resampled transects and plots originally established by Demarchi (1965) in 1963. Comparison among these sample years provides inferences regarding vegetation response to release from domestic livestock grazing.

Demarchi (1973a) concluded that only the bluebunch wheatgrass/junegrass community (Site d; Appendix G) on South Slope remained in relatively stable condition between 1963 and 1972. This community supported a presumed climax proportion of 47% and 49% foliar cover of bluebunch wheatgrass during the two sample years respectively. Successional species such as pasture sage declined slightly, while total bare ground diminished from 28 to 10 percent between 1963 and 1972.

Three plant communities on Flatiron Mountain showed marginally improved foliar cover of climax forage species. The junegrass/Sandberg's bluegrass community (Site g; Appendix G) on Starvation Flats displayed a 6% foliar cover of bluebunch wheatgrass in 1972, but only a 1% foliar cover of this species in 1963. Successional grasses, including junegrass and Sandberg's bluegrass declined from 28 to 10% and 32 to 22% foliar cover respectively. Unaccountably however, and in apparent contrast to these presumed improvements in plant succession, pasture sage and rabbitbrush increased from a total of 6% foliar cover in 1963 to 18% in 1972 (Demarchi 1973a). Such anomalies illustrate again that conclusions regarding changes in plant communities may be misleading when based upon only one or two floristic features.

The Columbia needlegrass/cheatgrass community (Site j; Appendix G) on South Slope displayed more consistent improvements between 1963 and 1972, as foliar cover of climax bluebunch wheatgrass increased from 5 to 20 percent. Moreover, cheatgrass declined from 12 to 0 percent foliar cover, while Columbia needlegrass, which dominated the site in 1963 (65%), declined dramatically to 19% foliar cover in 1972 (Demarchi 1973a).

Slight improvements also occurred in the seral pasture sage/junegrass community (Site e; Appendix G) originally sampled by Demarchi (1965) on Juniper Slope. Bluebunch wheatgrass (2%) and Idaho fescue (trace) both occurred in 1972, even though neither was recorded in 1963 (Demarchi 1973a). Correspondingly, Columbia needlegrass and pasture sage declined, while junegrass remained relatively unchanged in percent foliar cover.

Similar changes were displayed by another pasture sage/junegrass community (Site f; Appendix G) on South Slope, as foliar cover of bluebunch wheatgrass remained low in both 1963 (2%) and 1972 (4%), while junegrass and pasture sage both declined. Only Sandberg's bluegrass provided inconsistent trends, increasing from 8 to 18 percent foliar cover on Site e, but declining from 17 to 9 percent on Site f (Demarchi 1973a).

In contrast to these improvements however, three sites considered to be climax bluebunch wheatgrass/Idaho fescue communities on Flatiron Mountain in 1963 showed declines in foliar cover of climax species by 1972. Bluebunch wheatgrass equalled 30, 64 and 51 percent foliar cover on Sites a, b and c (Appendix G) in 1963, but only 26, 39 and 7 percent in 1972. Large declines in foliar cover of Idaho fescue also occurred on Sites a and b, while pasture sage increased from 3 to 10 percent foliar cover on Site a.

Reduced foliar cover of desirable forage species similarly occurred in two seral Kentucky bluegrass/Columbia needlegrass communities on Flatiron Mountain. Kentucky bluegrass equalled 82 and 76 percent foliar cover on Sites h and i (Appendix G) respectively in 1963, but equalled only 42 and 24 percent foliar cover in 1972. Moreover, neither bluebunch wheatgrass nor Idaho fescue were recorded in 1973, and both remained at 1% or below on both sites in 1972. Successional species such as pasture sage, wild buckwheat, cheatgrass and dandelion all increased on either or both sites h and i between 1963 and 1972 (Demarchi 1973a).

No published data exist regarding trends in foliar cover on Flatiron Mountain since 1972. Preliminary information is available however from resampling of Blood's (1961) original exclosure on South Slope, Scheffler's (1972) exclosures on South and Juniper Slopes, and Harper's (1969) exclosure on Juniper Slope (Harper 1983). In the bluebunch wheatgrass/junegrass community (Site d; Appendix D) on South Slope, total foliar cover increased outside the exclosure from 28% in 1967 (Scheffler 1972) to 80.4% in 1983 (Harper 1983). Virtually all plant species recorded by Scheffler (1972) shared such improvements in foliar cover. Improvements were particularly pronounced for Idaho fescue (trace-13.3%), junegrass (6%-13.9%) and bluebunch wheatgrass (14%-19.6%). Yarrow, which contributed only 3% foliar cover in 1960 (Blood 1961), equalled 20.3% in 1983 (Harper 1983).

Similar trends occurred at another South Slope exclosure site originally established by Scheffler (1972) in 1967, as total foliar cover increased from 21.5 to 51.2 percent between 1967 and 1983. Those plant species displaying largest increases in foliar cover included bluebunch wheatgrass (4.8-23.2 percent) and Idaho fescue (trace-10.8 percent). Junegrass remained relatively unchanged between 1967 (8.3%) and 1983 (6.2%).

Increases in foliar cover also occurred at two exclosure sites on Juniper Slope. Initial data provided by Harper (1969) indicated a 27% foliar cover in a pasture sage community, consisting of pasture sage (10%), Sandberg's bluegrass (8.8%), junegrass (3.7%), bluebunch wheatgrass (0.5%), Columbia needlegrass (trace) and yellow locoweed (4.0%). Resampling by Harper (1983) in 1983 revealed a total foliar cover of 88.2%, dominated by yellow locoweed (26.2%), pasture sage (17.9%), junegrass (14.9%), Columbia needlegrass (12.2%), Sandberg's bluegrass (8.7%) and bluebunch wheatgrass (2.2%).

At Scheffler's (1972) exclosure site on Juniper Slope, total foliar cover of grazed vegetation in 1967 equalled 36.9%, and consisted of bluegrass species (25.2%), junegrass (6.5%), Columbia needlegrass (3.3%) and bluebunch wheatgrass (0.7%). Resampling by Harper (1983) indicated 69.2%

total foliar cover dominated by Kentucky bluegrass (41.9%), yarrow (7.6%), Columbia needlegrass (6.1%), bluebunch wheatgrass (4.9%) and junegrass (3.8%).

No repeated sampling of transects or plots has occurred on Crater Mountain since 1967. Transects established by the British Columbia Ministry of Forests in 1981 however, indicated excellent plant cover in August 1982, with very low proportions of bare ground and rock on West Crater Basin (2.5%), Meausette Creek (3%) and Hargreaves Pasture (0.5%). Slightly higher proportions of bare soil and rock prevailed at South (7%) and North (10%) Crater Slopes.

Botanical information provided by the British Columbia Ministry of Forests (1982) is expressed in units of total plant hits and relative frequency rather than total foliar cover. The following values for percent botanical composition therefore, are not comparable directly to botanical information summarized previously. Nonetheless, these data suggest that palatable, often climax forage species, dominate all transect sites. Botanical composition on West Crater Basin equalled 30% pinegrass, 18% Kentucky bluegrass and 7% junegrass, plus 21 forbs contributing 33% botanical composition. Equivalent values at Meausette Creek equalled 17% Kentucky bluegrass, 8% bluebunch wheatgrass, 7% junegrass and 10% yarrow, plus 21 additional forbs totaling 53% botanical composition. Hargreaves Pasture was dominated by junegrass (20%), Kentucky bluegrass (15%), bluebunch wheatgrass (12%), yarrow (8%) and timber milkvetch (7%), plus 12 additional forbs (39%). Pinegrass and Kentucky bluegrass both contributed 26% botanical composition on South Crater Slope, followed by yarrow (8%), plus 15 other forbs equalling 30% botanical composition. Junegrass (17%), Sandberg's bluegrass (17%) and bluebunch wheatgrass (14%) all dominated North Crater Slope, with 14 forbs contributing 34% botanical composition (British Columbia Ministry of Forests 1982).

Impacts of Grazing on Foliar Cover and Botanical Composition

Observed changes in foliar cover between 1960 and 1983 may have resulted not only from altered grazing activities, but also from other factors, most notably variable annual weather patterns. For example, Demarchi's (1973a) foliar cover data collected on Flatiron Mountain transects in both 1971 and 1972 reveal striking differences in absolute values which were unlikely caused by successional changes induced during one additional year of rest from livestock grazing. Specifically, bluebunch wheatgrass on Site d (Appendix G) increased from 35% foliar cover in 1971, to 49% in 1972, while percent bare ground declined from 30% to only 10% during this same time period. Other sample areas (Appendix G) produced similar large declines in percent bare ground between 1971 and 1972, including Site b (18%-3%), Site c (60%-27%) and Site e (31%-10%). Moreover, foliar cover of Columbia needlegrass in the bluebunch wheatgrass community (Site e; Appendix G) on Juniper Slope equalled 25% in 1971, but only 3% in 1972.

Demarchi (1973a) attributed some of the changes in foliar cover values between 1963 and 1972 to drying climatic trends in the Ashnola, although no data were provided to support this hypothesis. Nonetheless, Demarchi (1973a) conjectured that apparent declines in range conditions on transect areas which supported climax vegetation in 1963 may have resulted from such drying trends. Conceivably also, intense livestock grazing pressure between 1964 and 1968 may have precipitated declines in foliar cover, such that 3-4 growing seasons of rest between 1969 and the 1971-1972 sample dates proved insufficient for recovery of vegetation to 1963 foliar cover levels. Once again however, no data exist to support or refute such conjectures.

Grazing exclosures provide the primary mechanism by which to distinguish foliar changes produced by altered grazing practices from those foliar changes initiated by variable annual weather patterns. If similar changes in foliar cover values over time occur both inside and outside grazing exclosures, then variable weather patterns likely produced such changes. Alternatively, different trends in foliar cover values inside and ouside grazing exclosures are explained most likely by altered grazing activities.

In order to make this distinction, Scheffler (1972) collected botanical information in 1967 from transects located both inside and outside exclosures established by Blood (1961) in 1960. Although total foliar cover declined from 57% in 1960 to 28% in 1967 on grazed transects in a Columbia needlegrass community (Site j; Appendix E), relatively similar declines to 37% foliar cover also occurred inside the exclosure where no livestock grazing existed. Similarly, parallel declines in foliar cover ocurred between the interior and exterior of 3 other exclosures sampled by both Blood (1961) and Scheffler (1972). In a bluebunch wheatgrass/junegrass community (Site d; Appendix E) on South Slope, foliar cover equalled 40% in 1960, but only 32 and 30 percent respectively inside and outside the exclosure in 1967. Two exclosure sites on Crater Mountain (Appendix F) provided 52 and 66 percent foliar cover in 1960, declining to 16 and 20 percent respectively in grazed areas by 1967. However, total foliar cover inside these two exclosures, protected from livestock grazing, similarly declined to 22 and 16 percent respectively by 1967.

Relatively similar trends inside and outside the exclosures also occurred for foliar cover of specific plant species. While bluebunch wheatgrass declined under grazing pressure from 20-5 percent and 22-9 percent at two sample sites on Crater Mountain (Appendix F), nearly equivalent declines also occurred within the exclosures, where bluebunch wheatgrass equalled only 11 and 10 percent foliar cover respectively in 1967. Moreover, junegrass displayed virtually identical foliar covers inside (4.5%) and outside (5.0%) the two exclosures, while Idaho fescue provided only a minor component of both grazed and protected areas in 1967, even though it equalled 13% foliar cover at one exclosure in 1960 (Scheffler 1972).

Exclosures on South Slope exhibit less consistent trends in foliar cover. Bluebunch wheatgrass increased from 6 to 17 percent foliar cover under protection from livestock grazing on Site j, but declined outside the exclosure to only 2% foliar cover by 1967 (Scheffler 1972). In contrast, bluebunch wheatgrass increased from 11% foliar cover in 1960 to 14% in 1967, both inside and outside a second exclosure located on Site d. Moreover, junegrass declined under protection, from 10%-trace and 8%-2% foliar cover by 1967, compared to 6 and 10 percent respectively in areas grazed by livestock. Columbia needlegrass remained virtually unchanged in grazed areas on Site j between 1960 (14%) and 1967 (14%), but declined with grazing protection to 4 percent foliar cover between 1963 and 1972.

Demarchi (1973a) provided no botanical information within grazing exclosures, thereby precluding assessment of the relative impacts of livestock grazing and weather patterns on foliar cover changes between 1963 and 1972. Harper (1983) however, resampled both inside and outside the small exclosure established by Blood (1961) in 1960 in a bluebunch wheatgrass/junegrass community (Site d; Appendix D) on South Slope. This area has been grazed only by California bighorn sheep since 1968, and reveals striking botanical differences inside and outside the exclosure. Most notably, Kentucky bluegrass equalled 52.7% foliar cover inside the exclosure, but only 3.2% under grazing by bighorn sheep. Alternatively, much lower foliar cover values existed under protection from sheep grazing for bluebunch wheatgrass (0.6%), junegrass (3.6%) and Idaho fescue (1.8%) than for transects outside the exclosure, where foliar cover for these three plant species equalled 19.6, 13.9 and 13.3 percent respectively. Yarrow however, dominated vegetation both inside and outside the exclosure, equalling 26.7 and 20.3 percent foliar cover respectively.

Similar results were obtained at the exclosure established by Scheffler (1972) on South Slope. Bluebunch wheatgrass equalled 23.2% in grazed vegetation, compared to only 12.6% foliar cover inside the exclosure. Foliar cover of protected Idaho fescue (25.0%) exceeded that of grazed vegetation (10.8%), while junegrass remained relatively unaffected by bighorn sheep grazing, equalling 8.6 and 6.2 percent foliar cover inside and outside the grazing exclosure respectively (Harper 1983).

Resampling of Harper's (1967) exclosure on Juniper Slope yielded different conclusions regarding the impact of grazing on trends in foliar cover. This area of Juniper Slope has been grazed by cattle since 1977.

Correspondingly, bluebunch wheatgrass, which contributed only 0.5% foliar cover in 1967 (Harper 1969), equalled 11.0% in 1983 under protection from grazing, but only 2.2% outside the exclosure (Harper 1983). Similarly, Columbia needlegrass, which occurred as only a trace in 1967, provided 23.8% foliar cover inside the exclosure compared to only 12.2% in grazed areas. In contrast, foliar cover increment of junegrass since 1967 (3.7%) was greater outside (14.9%) than inside (9.7%) the exclosure. Similarly, Sandberg's bluegrass, also a small bunchgrass, maintained 8.7% foliar cover outside the exclosure between 1967 and 1983, but dropped to 4.0% under protection from cattle grazing. Pasture sage inside the exclosure (13.2%) remained relatively unchanged compared to 1967 (10%), but increased to 17.9% foliar cover under grazing pressure. Yellow locoweed in grazed areas displayed a similar response to pasture sage, increasing to 26.2% foliar cover in 1983 from 4.9% foliar cover in 1967. Under protection from grazing, yellow locoweed remained at 4.9% foliar cover (Harper 1983).

Resampling of Scheffler's (1972) exclosure on Juniper Slope provided similar conclusions regarding the impacts of cattle grazing. Bluebunch wheatgrass increased from 0.7% foliar cover in 1967 to 11.7% foliar cover following protection from grazing. This contrasted with a foliar cover increase to only 4.9% outside the exclosure. Alternatively, Kentucky bluegrass, which equalled 25.2% in 1967, increased to 41.9% in grazed areas, but declined to 12.8% in protected vegetation. Junegrass and Columbia needlegrass displayed relatively similar foliar cover changes both inside and outside the exclosure between 1967 and 1983 (Harper 1983).

Conclusions regarding the impact of grazing management on plant succession and range condition, based upon foliar cover values, may be misleading. Successional stage, and therefore range condition, is determined best by botanical composition, which reflects the relative proportion of plant species as a function of grazing management (Pitt 1984). Alternatively, absolute foliar cover values reflect not only botanical composition, but also current growing conditions, which may mask true botanical composition, perhaps leading to the large differences in foliar cover recorded by Demarchi (1973a) between 1971 and 1972.

Blood (1961) provided data for the relative contribution of each plant species to total plant cover, thereby providing an opportunity to assess botanical composition. However, Demarchi (1965), Demarchi (1973a) and Harper (1983) all estimated absolute foliar cover based upon quadrats, precluding determination of relative botanical composition. Although Harper (1969) collected botanical information based upon individual plants, previous comparisons with resampling by Harper (1983) were based upon absolute foliar cover rather than relative botanical composition in order to provide consistency with the techniques employed by Harper (1983).

Blood (1961) indicated that such conversion of individual frequency of plants to percentage ground cover assumes directly proportional relationships. Previous comparisons of botanical data collected by Blood (1961) with resampling by Scheffler (1972) were based upon conversion of Blood's (1961) botanical composition data to percent foliar cover, assuming this proportional relationship. Although Scheffler (1972) collected relative botanical composition on some research sites, values obtained by resampling Blood's (1961) exclosures were reported as absolute foliar cover, with no indication of the proportion of individual plants comprising that foliar cover.

Differences in foliar cover and botanical composition may be quite large. For example, in the bluebunch wheatgrass/junegrass community (Site d; Appendix G) on South Slope, foliar cover values for bluebunch wheatgrass, junegrass and Kentucky bluegrass equalled 11, 10 and 4 percent respectively in 1960, compared to corresponding values of 28, 26 and 10 percent botanical composition (Blood 1961).

The previous discussions therefore assume that conclusions regarding the impacts of grazing in the Ashnola would be similar in principle to conclusions based upon botanical composition. Such an assumption is required for inferences regarding plant succession and vegetation changes as a function of livestock and California bighorn sheep grazing management activities between 1960 and 1983. The following items summarize such inferences:

1. Total foliar cover on Crater and Flatiron Mountains between 1960 and 1967 declined significantly both inside and outside grazing exclosures, indicating response not only to grazing pressure, but also to the influence of variable annual weather patterns.
2. Foliar cover of bluebunch wheatgrass, junegrass and Idaho fescue on Crater Mountain between 1960 and 1967 declined both inside and outside grazing exclosures, indicating response not only to grazing pressure, but also to the influence of variable annual weather patterns.
3. Foliar cover of bluebunch wheatgrass improved under protection from

grazing at one South Slope exclosure between 1960 and 1967, but remained relatively unaffected by grazing protection at a second exclosure. Junegrass increased in grazed compared to protected areas, while Columbia needlegrass remained relatively unaffected by grazing activities on South Slope during this time period.

4. Botanical changes between 1963 and 1972 on Flatiron Mountain provide inconclusive conclusions, as climax and seral forage species displayed both increases and/or decreases in foliar cover, with the magnitude and direction of change varying among sample sites.
5. Two South Slope sites grazed primarily by California bighorn sheep since 1968 demonstrated increased proportions of bluebunch wheatgrass and Idaho fescue, compared to ungrazed vegetation, between 1960 and 1983. Kentucky bluegrass increased with protection from sheep grazing, while relatively high proportions of yarrow persisted at one site regardless of sheep grazing intensity.
6. Juniper Slope sites grazed by cattle since 1977 demonstrated generally increased proportions of junegrass, Sandberg's bluegrass, pasture sage and yellow locoweed, compared to ungrazed vegetation, between 1967 and 1983. Bluebunch wheatgrass declined in areas not protected from cattle grazing.

These conclusions are based upon data representing variable sample dates, sizes and techniques. Such summaries must necessarily be considered as correlative and indicative, rather than conclusive or absolute.

Forest Encroachment

Potential loss of grassland due to forest encroachment produces concern among livestock and wildlife grazing management personnel. Such concerns are predicated on the historical occurrence of fires in the Ashnola (Harcombe and Kowall (1982), as well as aerial photographs which suggest that lodgepole pine, Engelmann spruce and Douglas-fir have all become established on some heavily grazed grasslands (Scheffler 1972). Field observations also indicate encroachment of trembling aspen (poplar) onto moist grasslands of Crater Mountain.

Harcombe and Kowall (1982) investigated forest encroachment on Flatiron Mountain, and reported 6 major fires since 1840. These fires occurred primarily in forested plant communities, producing more seral stands of lodgepole pine. Harcombe and Kowall (1982) found no evidence to support the hypothesis that present grasslands were previously forested. Indeed, grasslands on Flatiron Mountain exist under climatic conditions drier and hotter than regional norms, presumably because of topographic southern exposures in conjunction with drying winds from the west. Moreover, Harcombe and Kowall (1982) conjectured that drought tolerant grasslands may replace forests on some exposed aspects if fires occurred during periods of extended drought.

Harcombe and Kowall (1982) concluded that very little evidence existed to confirm concerns of widespread forest encroachment onto the grasslands of Flatiron Mountain. Indeed, the boundary between grassland soils

(Chernozems) and forest soils (Podzols) was quite distinct, correlating almost exactly with current forest margins. Even scattered tree encroachment into the grasslands was considered negligible.

Harcombe and Kowall (1982) recorded Ah horizons for Orthic Black Chernozems and Orthic Dark Brown Chernozems of 20-50 cm (8-20 inches) and 10-30 cm (4-12 inches) respectively. Harcombe and Kowall (1982) further commented that Ah horizons of 10 cm (4 inches) thickness often require greater than 100 years to develop, providing additional evidence that current grasslands have remained essentially stable during the last 250 years.

Consequently, concerns regarding extensive loss of grassland due to forest encroachment on Flatiron Mountain appear unfounded. However, investigation of forest encroachment on Crater Mountain has not been conducted, thereby precluding definite conclusions. Boundaries between grassland and forest communities are certainly dynamic, and likely fluctuate locally in response to short-term drying and wetting trends in moisture availability. Such vegetation boundaries, particularly on Crater Mountain, should be observed closely, with continued perceived encroachment documented carefully. Localized treatment, particularly in moist areas, will likely be sufficient to prevent significant forage losses due to forest encroachment.

ECOLOGY OF CALIFORNIA BIGHORN SHEEP IN THE ASHNOLA REGION

The Ashnola supports two herds of California bighorn sheep wintering on Flatiron and Crater Mountains respectively (Blood 1963a). Although these bands are commonly considered relatively distinct, unpublished evidence suggests that movement of ewes from Crater Mountain to South Slope on Flatiron Mountain occasionally occurs during winter. Some of these ewes remain on the Ewart Creek lambing grounds for lambing prior to returning to Crater Mountian in the spring. Historically, both of these sheep herds may have utilized the Similkameen Valley for winter range, gaining access down the Ashnola River. These two bands are collectively referred to as the Ashnola population of California bighorn sheep.

Seasonal Distribution And Habitat Selection

The pronounced relief of the Ashnola Region reduces the need for long distance migrations by bighorn sheep. (Blood 1961, 1963a). Seasonal movements are thus localized, involving shifts between summer range in the alpine and subalpine zones at 1800 to 2600 m (6000 to 8500 ft) elevation, to winter-spring range on southerly exposed slopes of the Ashnola River trench (Sugden 1961, Blood 1963a). Demarchi (1965) estimated that 60% (150 of an estimated 250 animals) of the bighorn sheep wintered on Flatiron Mountain ranges.

Total time spent on the winter-spring ranges is less for rams than for ewe:lamb:yearling groups. Blood (1961, 1963a) found that rams left winter-spring ranges earlier, and returned later, than the matriarchal groups. Ram migration began in late May or early June, with animals drifting gradually up to the alpine by late June. No rams were observed on winter ranges during July, August and September (Blood 1961, 1963a). In contrast to rams, matriarchal groups remained on the winter-spring ranges until early July. Their departure however, was a distinct exodus rather than a gradual drift. From early July to early October, Blood (1961, 1963a) reported only 1 ewe group on winter ranges. Fall migration back to the lower elevations occurred from mid- to late October, with ewe groups generally preceding the rams.

Blood (1961, 1963a) reported that rams and ewes on Crater Mountain shared a common summer alpine range, although not in close proximity. East of the Ashnola River however, rams and ewes segregated immediately following spring migration. Alpine ranges on Observation Mountain and Joe Lake were used almost exclusively by rams, while those around Haystack Mountain and Cathedral Lakes were used by the ewe groups.

Such differential migration of the sexes may result from differential selection of habitat types (Blood 1961, 1963a). In ewe groups, habitat selection is strongly governed by the availability of escape terrain (Blood 1961, 1963a). Ewe groups must consequently travel a greater distance (13 to 19 km; 8-12 miles), crossing both the Ashnola River and an expanse of timbered range, before gaining habitat which is characterized by precipitous slopes at high elevations. Rams, with a lower requirement for escape terrain, travelled only 8 to 10 km (5 to 6 miles) to occupy areas characterized by rolling terrain (Blood 1961, 1963a).

Demarchi (1965) investigated habitat selection by California bighorn sheep on Flatiron Mountain, and recorded a significantly higher use of climax plant communities, as assessed by the proportion of bluebunch wheatgrass. Preference for these habitats was related to degree of slope as well as vegetative cover. Based upon pellet group distribution, highest sheep use occurred on sites exceeding 25 degrees slope, while lowest use by sheep was recorded for level terrain less than 5 degrees slope. Demarchi (1965) further concluded that livestock overgrazing had eliminated all climax communities on sites less than 12 degrees slope, thereby eliminating the potential to assess the relative importance of slope and plant community in habitat selection by bighorn sheep.

Scheffler (1972) provided qualitative assessment of habitat selection, and reported late winter-early spring bighorn sheep use of bluebunch wheatgrass/junegrass communities associated with lower montane forests. Sheep seldom utilized mid-montane forest with pinegrass understory, except as escape terrain or travel routes.

Kornet (1978) studied habitat selection of California bighorn sheep on Hart Mountain in Oregon, and developed preference indices based upon proportions of habitat availability and time spent by ewe groups in each of 10 habitats. Shrub habitats associated with cliffs provided highest preference indices for both feeding and total activity budgets of ewe groups. Secondarily preferred habitats included basins surrounded by rocky, steep slopes, plus a plateau of rugged terrain at higher elevation, dominated by big sagebrush and low sagebrush respectively. Habitats dominated by Idaho fescue were lightly preferred for feeding in summer and spring, but were selected against during fall months. Big sagebrush/bluebunch wheatgrass habitats provided preference indices less than 1.0 for feeding and total activity budgets during summer, fall and spring.

Kornet's (1978) conclusions support those of Demarchi (1965) and Scheffler (1972), who similarly observed that habitat selection depends upon a variety of factors, including slope, accessibility, presence of escape terrain and vegetative cover. These relative factors remain to be identified explicitly in the Ashnola region. Moreover, migration patterns have likely altered since those summarized by Blood (1961, 1963a). For example, field observations reveal bighorn sheep utilization of South Slope and Juniper Slope during all months of the year except August. Consequently, new intensive information is required regarding migrational patterns of California bighorn sheep in the Ashnola, particularly in relation to preferred habitats during specific portions of the calendar year.

Foraging Preferences and Activities

Sugden (1961) characterized California bighorn sheep as opportunistic feeders, which adapt their diets to forage availability. Correspondingly, pasture sage and bluebunch wheatgrass, which co-dominated Sugden's (1961) research site at Sheep's Flat, provided the primary winter forages of the Churn Creek bighorn sheep herd, comprising 47.5 and 17.1 percent of observed foraging activities respectively. These two forage species provided approximately equal availability, prompting Sugden (1961) to conclude that pasture sage constituted a preferred winter forage, particularly during years of light snow accumulation. Although no data were provided, summer diets of Churn Creek bighorn sheep in alpine ranges included wheatgrass, sheep fescue, alpine bluegrass and sedges (Sugden 1961).

Blood (1961, 1967), Demarchi (1965) and Morrison (1972) all summarized foraging activities of bighorn sheep on Flatiron Mountain. These investigations employed variable experimental techniques, including rumen analysis (Blood 1961, Demarchi 1965, Morrison 1972), observation of feeding (Blood 1961, Morrison 1972), plus counting of grazed stems in areas known to be grazed by only one animal species (Morrison 1972).

Sampling bias unique to each of these techniques limits direct comparability among forage preference studies. Nonetheless, consistent generalizations regarding foraging activities and diet preferences are evident.

Demarchi (1965) collected 4 bighorn sheep rumens during the winter of 1963, and observed 88.1% grass species by volume. Pasture sage contributed 5.0%, followed by wild buckwheat at 4.0%. Although individual grass species were not identified, Demarchi (1965) incorporated data collected by Blood (1961) to calculate the following relative importance values of winter forages: bluebunch wheatgrass (59), Sandberg's bluegrass (13), junegrass (8), Idaho fescue (7) and pasture sage (5).

Blood (1961) utilized grazed stem counts supplemented by observations of cratering in snow, and observed that bluebunch wheatgrass and Sandberg's bluegrass constituted high percentages of sheep diet during winter on South Slope, equalling 22.4 and 11.8 percent respectively in December. Pasture sage however, comprised an even larger proportion of the diet, equalling 41.7% of observed foraging activities. Indeed, Blood (1961) observed bighorn sheep to crater through several inches (cm) of snow to obtain pasture sage, even when abundant bunchgrass protruded above the snow. By May however, pasture sage declined to 28% of the diet, while bluebunch wheatgrass increased to 49.4 percent.

With advent of spring, during the month of June, grasses comprised a very large proportion of the diet at 95%, consisting of bluebunch wheatgrass (47.1%), junegrass (18.3%), bluegrass (15.9%) and cheatgrass (13.3%). Pasture sage became a minor component of the June diet at 1.2 percent. Blood (1961) indicated that cheatgrass, normally considered an unpalatable annual, was selected only during May and early June, perhaps prior to maturity and development of potentially injurious awns. Blood (1961) provided no data regarding summer diets, but qualitatively noted the importance of sheep fescue, alpine bluegrass and timber oatgrass. Shrubs remained minor components of the diet during all times of the year.

Morrison (1972) collected 3 bighorn sheep rumens between May and June, and reached conclusions similar to Blood (1961). Grasses comprised the most important component of the spring diet, equalling 91% of rumen contents expressed on a dry weight basis. Forbs, primarily silky lupine and white leaf phacelia, contributed only 7.0%, followed by wild buckwheat at 2.1

percent. Two rumens collected during winter on Juniper Slope contained 89% unidentified grasses and 10% browse, consisting of wild buckwheat (4.7%), pasture sage (3.4%) and Douglas-fir (2%).

Wikeem and Pitt (1979) indicated that proper interpretation of diet requires information regarding forage availability, particularly when conclusions are to be made relative to forage preference. Specifically, forage preference inferred solely from ingested material may represent consumption of available forage rather than preferred forage per se. Indeed, Morrison (1972) observed that bighorn sheep tended to graze forage in relation to its availability on South Slope. Consequently, Morrison (1972) documented summer forage selection on South Slope, from July 5-7, relative to availability of all forage plants.

Results exist for two plant communities which are characterized by bluebunch wheatgrass and bluebunch wheatgrass/pasture sage respectively. On the bluebunch wheatgrass site, grass constituted the forage class most frequently grazed, comprising 63.6% of all grazing activities, followed by forbs (26.5%) and browse (5.9%). Primary plant species ingested included junegrass (27.9%), bluebunch wheatgrass (26.0%), Idaho fescue (9.7%), yarrow (7.8%) and silky lupine (7.1%). However, although forbs formed a smaller proportion of the diet than grasses, California bighorn sheep displayed a stronger forage selection for forbs during early summer (Morrison 1972). Plants with highest selection indices, in descending order, included nodding onion, timber milkvetch, wild buckwheat and silky lupine (Morrison 1972). Intermediate forage preference was displayed for Idaho fescue, junegrass and pasture sage. Of those plant species consumed, bighorn sheep displayed lowest forage preferences for yarrow and bluebunch wheatgrass.

Similar results occurred in the bluebunch wheatgrass/pasture sage community on South Slope. Forages most commonly consumed included bluebunch wheatgrass (34.0%), Sandberg's bluegrass (29.9%) and pasture sage (8.2%). Rankings based upon relative forage availability however, indicated highest sheep preference, in decreasing order, for nodding onion, Sandberg's bluegrass, silky lupine, Idaho fescue, yarrow and rosy pussytoes. Sheep exhibited lowest preferences of ingested forages for junegrass, bluebunch wheatgrass and pasture sage. Selection indices were not determined for the spring, fall, or winter seasons.

Wikeem (1984) developed monthly forage preference indices throughout a 28 month period for a captive California bighorn sheep herd on the Okanagan Game Farm during 1977 and 1978. Results are similar to those provided by investigations on Flatiron Mountain. Grasses comprised the highest average proportion of the diet at 66.3%, followed by forbs (18.6%) and shrubs (14.7%). Bluebunch wheatgrass provided the single most dominant forage species during all seasons except the fall of 1978, when junegrass occurred more frequently in the diet. Bluebunch wheatgrass comprised highest proportions in winter (26.7 and 30.8 percent) and least in summer (15.7 and 18.0 percent). Despite such prominence in the diet however, the captive herd displayed forage preference indices less than 1.0 for bluebunch wheatgrass during all months except February 1978. Preferred bunchgrasses included rough fescue, Idaho fescue, junegrass and needleandthread.

Forbs attained highest diet proportions in spring (19.2 and 18.4%) and summer (26.5 and 36.2%), but became less important with advancing phenology.

Forbs with high preference indices included balsamroot, silky lupine, Thompson's paintbrush, rock cress, thread-leaf fleabane, brown-eyed Susan, three-flowering avens, lemonweed and long-leaved phlox (Wikeem 1984).

Browse attained highest diet proportions during winter (18.7%) and spring (17.6%), with Douglas maple, saskatoon, pasture sage, snow buckwheat, wild buckwheat, mock orange, choke cherry, rose and snowberry all displaying high preference indices. The dominant shrub, big sagebrush, was strongly selected against during all seasons (Wikeem 1984).

The results presented by Wikeem (1984) corroborate the observations of Sugden (1961) and Morrison (1972) that California bighorn sheep employ opportunistic feeding patterns. Indeed, during the 28 month study, 80 plant species were observed in the sheep diet, including 14 grasses, 47 forbs and 19 woody plants (Wikeem 1984). Diets of California bighorn sheep in the Ashnola similarly tend to correspond with available forages. However, those plant species such as bluebunch wheatgrass and pasture sage, which often contribute large proportions of total diet, particularly during winter, do not always coincide with preferred forages when expressed relative to available plant species.

Toxic Plants

Three plants known to be toxic to domestic livestock are utilized by California bighorn sheep in the Ashnola. Death camas causes loss of domestic sheep on spring and summer ranges, primarily because of advanced spring growth compared to other, more preferred forages (Dayton 1937).

Although Blood (1961) reported spring grazing of death camas by California bighorn sheep, no ill effects were observed. Presumably, biomass consumption of death camas remained below the toxic levels of 0.91-1.13 kg (2.0-2.5 lbs) of green weight per 45.4 kg (100 lbs) of body weight (Lodge, et al. 1968).

Morrison (1972) reported that timber milkvetch comprised 5.8% of all plants grazed, by weight of total rumen contents, in a bluebunch wheatgrass community on South Slope. Although this plant produces a narcotic-like dependency, with subsequent weight loss and lowered reproductive potential in lactating cows, (Lodge, et al., McLean 1979), effects on bighorn sheep remain unknown. Morrison (1972) however, observed no declines in physical condition of sheep ingesting timber milvetch on South Slope, even though this plant species displayed the second highest summer forage preference index in a bluebunch wheatgrass community.

The third highest forage preference index reported by Morrison (1972) was for silky lupine, a plant species mildly poisonous to livestock. However, domestic sheep may consume up to 9.17 kg (20 lbs) of foliage or 0.23-0.68 kg (0.5-1.5 lbs) of seed before suffering death. In agreement with Morrison's (1972) observations, Blood (1961), Demarchi (1965) and Wikeem (1984) all reported selective grazing of silky lupine by bighorn sheep at various times of the year without observable toxic symptoms.

No losses of California bighorn sheep due to poisonous or toxic plants in the Ashnola are confirmed or even suggested in published literature. Apparently therefore, such losses are negligible, perhaps reflecting (1) relative non-susceptibility of bighorn sheep to plant species known to be toxic to livestock, and/or (2) ingestion of small amounts of toxic plants relative to other forages comprising the total diet.

Social Behavior

Blood (1961, 1963a) provided the most detailed summaries of Ashnola California bighorn sheep social behavior activities. Generally, during both summer and winter, the Ashnola herd divided into smaller bands, separated by as much as 24 km (15 miles) on summer ranges. More restricted winter ranges produced less spacing, with sheep densities between late October and June equalling 19-23/square km (50-60/square mile). During this period, sheep groupings became tenuous, with frequent dispanding and coalescing producing variable group composition and sizes.

Average group size between May 1, 1960 and June 30, 1961 equalled 9.3, ranging from solitary individuals to 75 animals. During one occasion, when alarmed by Blood (1963a) on South Slope, 140 sheep herded together in a single group. Ewe groups averaged 10.7 individuals, peaking in June following lambing. Ram group sizes averaged 6.1, with smallest numbers observed between October and December, prior to peaks in spring. Mixed groups, averaging 12.6 animals, were most common on winter ranges between October and February. Peak proportions of mixed groups, as a percentage of all sheep groups, corresponded with rutting during November (Blood 1961, 1963a).

Peak rutting activities occurred between mid- and late November, with earliest and latest observations of rams in rutting condition between

October 13 and February 6 respectively. No copulations however, were observed for either of these two extremes. Rams 3 years and younger displayed only casual sexual interest in ewes. All rutting activities were confined to winter ranges and immediate vicinity. Rutting rams showed no usual fears of man (Blood 1961, 1963a).

Lambing season extended from late April to mid-June, with a peak occurring in late May. Blood (1961, 1963a) reported first sightings of one to two week old lambs on May 7, 1960 and May 2, 1961 respectively. Harper (1984) similarly identified parturition in 1983 on Flatiron Mountian as lasting from April 22 to May 22. Known lambing grounds were confined primarily to precipitous cliffs and rock outcroppings immediately adjacent to grassland slopes utilized as spring range. Weaning of lambs occurred between 5 and 6 months of age (Blood 1961, 1963a).

Optimal Habitat for Sheep

Blood (1961, 1963a) believed that adequate escape terrain in proper juxtaposition with grassland slopes constitutes "prime requisite of bighorn sheep habitat selection, particularly of ewe-lamb groups." Kornet (1978), working in Oregon, similarly concluded that habitat selection by ewe-lamb groups was strongly motivated by the presence of major cliff locations adjacent to feeding areas. Indeed, Blood (1961) postulated that lower sheep numbers on Crater Mountain compared to South Slope resulted primarily from a lack of suitable escape terrain. Spring grassland ranges adjacent to escape terrain on Crater Mountain are relatively flat and snow-covered during winter. Alternatively, steep bunchgrass ranges on Crater Mountain, potentially available for winter use by sheep, are surrounded by Douglas-fir forest, which offers little value as escape terrain. In contrast, South Slope on Flatiron Mountain provides both spring and winter ranges immediately adjacent to suitable escape terrain.

Optimal habitat for Ashnola bighorn sheep also requires a variety of plant communities differing in phenological development and environmental attributes. Blood (1961, 1963a) observed that spring migration on Flatiron and Crater Mountains correlated with high temperatures on the winter ranges, which produced a dry, mature, herbaceous forage. Migration to higher elevation summer ranges provided greener forage at earlier phenological development, as well as animal relief from summer heat. Blood (1961, 1963a) noted that annoying insects were more abundant on summer than winter ranges, and therfore not a factor stimulating spring migration.

Snowstorms in the alpine-subalpine zone begin as early as late August in the Ashnola, with fall migration of sheep corresponding with arrival of permanent snow cover (Blood 1961, 1963a). Plant communities at lower elevation are therefore essential to provide forage, as well as opportunity for reproductive activity unencumbered by snow.

Sugden (1961) concluded that a suitable variety of forage species constitutes a basic habitat requirement of California bighorn sheep. The previous discussion summarizing foraging habits and preferences clearly indicates that sheep display opportunistic feeding patterns, and utilize many plant species in response to availability and/or palatability. Grasses, particularly bluebunch wheatgrass, provide major portions of sheep diet during winter and spring, while pasture sage has also been identified as an important constituent of early winter diets.

Forages which provide needed bulk however, particularly during critical winter periods, do not always correspond with plant species apparently preferred by California bighorn sheep. Specifically, smaller forages such as nodding onion, timber milkvetch, wild buckwheat, silky lupine, Idaho fescue, junegrass and Sandberg's bluegrass all displayed higher forage preference ratings for Ashnola bighorn sheep consumption than did bluebunch wheatgrass, the most commonly ingested forage. Moreover, sheep preference for forages varies among seasons, particularly for such plants as pasture sage, which is sought preferentially by sheep in early winter, but becomes relatively ignored during summer. Research at the Okanagan Game Farm (Wikeem 1984) supports these results obtained on Flatiron Mountain, as grasses, forbs and woody plants all displayed different seasonal peaks in forage preference indices.

Optimal proportions of forage species and plant communities may not require climax vegetation, and may even be enhanced by seral stages of plant succession. For example, Harper's (1983) data from resampling both Blood's (1961) and Scheffler's (1972) exclosures on South Slope suggest that virtually exclusive bighorn sheep grazing since 1968 encouraged succession toward a presumed climax community dominated by bluebunch wheatgrass and junegrass, but away from seral plants perhaps more preferred by sheep. Specifically, successional Kentucky bluegrass dominated vegetation inside the exclosure (52.7% foliar cover), but equalled only 3.2% foliar cover outside the exclosure. Assuming that sheep expressed their forage preferences between 1968 and 1983, Kentucky bluegrass was likely grazed selectively by sheep outside the exclosure, thereby hastening succession towards a plant community characterized more by climax, albeit apparently less preferred forage species. Certainly such inferences based upon a single exclosure should be viewed as highly speculative. Nonetheless, field observations by the senior author at the Okanagan Game Farm study site supports a conclusion of sheep selection for Kentucky bluegrass, which was preferentially grazed where it occurred in moist draws. Such Kentucky bluegrass communities are usually very productive, particularly when compared to regional climax plant communities. For example, Kentucky bluegrass vegetation on Flatiron Mountain averaged 2660 kg/ha (2375 lbs/acre) in 1972, compared to only 1539 kg/ha (1374 lbs/acre) for bluebunch wheatgrass/Idaho fescue (Appendix D).

Scheffler (1972) commented that seral plant communities may occasionally yield more forage biomass than climax vegetation, a conclusion supported by other production values summarized in Appendix D. Plant communities dominated by climax bluebunch wheatgrass/Idaho fescue and bluebunch wheatgrass/junegrass averaged 1539 and 1411 kg/ha (1374 and 1260 lbs/acre) respectively in July, 1972. Successional communities such as pasture sage/junegrass and junegrass/Sandberg's bluegrass averaged only 680 and 945 kg/ha (608 and 844 lbs/acre) respectively. Other successional communities however, provided greater forage production. Kentucky bluegrass/Columbia needlegrass and Columbia needlegrass/cheatgrass communites equalled 1700 and 1791 kg/ha (1518 and 1599 lbs/acre), exceeding the production of the two plant communities characterized by climax species.

Although site variability may limit the value of direct comparisons, the production figures illustrate that seral plant communities can provide significant amounts of available forage. Moreover, those plant species often associated with seral stages, such as pasture sage, are preferentially grazed by bighorn sheep during portions of the calendar year. Even cheatgrass, normally considered an undesirable successional species, provided 13.3% of sheep diet during the spring of 1961 (Blood 1961), a time of the year when forage availability, and presumably selection of preferred forages, is high. Moreover, the Columbia needlegrass/cheatgrass community exceeded bluebunch wheatgrass dominated communities in terms of average forage production (Appendix D).

Demarchi (1973b) investigated the impact of successional stage on California bighorn sheep on the Junction Unit near Riske Creek, British Columbia. Based upon pellet group distribution, sheep displayed apparent preference for seral plant communities dominated by Columbia needlegrass/bluebunch wheatgrass/Sandberg's bluegrass compared to climax bluebunch wheatgrass/Sandberg's bluegrass. Moreover, Demarchi (1973b) reported more crude protein per unit area available in these seral communities compared to climax vegetation, perhaps encouraging selection by bighorn sheep.

Such inferences regarding cause for bighorn sheep habitat and/or forage selection however, must be assessed carefully. For example, Wikeem (1984) developed multiple linear and multiple stepwise polynomial regressions among sheep diet, plant cover and nutritive quality characterized by percent nitrogen, calcium, phosphorus and the calcium/phosphorus ratio. Wikeem

(1984) concluded that only plant cover correlated consistently with diet selection, while no statistically significant generalizations emerged between selected plant species and specific nutritive quality parameters. Alternatively, Demarchi (1965) measured generally lower levels of nitrogen, phosphorus and calcium during winter in bluebunch wheatgrass, Idaho fescue, Sandberg's bluegrass and Columbia needlegrass compared to yarrow, wild buckwheat and pasture sage, offering at least correlative explanation for observed selection preferences for these last two species during winter.

Precise statements regarding optimal California bighorn sheep habitat are perhaps inappropriate because of environmental variability among years. Biological systems display inherent, dynamic fluctuations rather than predictable stability. The following summary however, characterizes anticipated optimal bighorn sheep habitat based upon the previous discussions.

Escape terrain, adjacent to spring ranges, is essential for ewe/lamb groups. Spring ranges should support a mixture of grasses and forbs. Grasses provide consistenly high proportions of documented bighorn sheep spring diet, while forbs often constitute preferred forages. Alpine/subalpine summer ranges offer respite from heat at lower elevation winter/spring ranges, plus availability of forages at earlier, more nutritious stages of phenology.

A mosaic of plant communities, providing a wide variety of forage species allows bighorn sheep to express opportunistic grazing preferences. Grasses, forbs and woody plant species all contribute important forage constituents during different portions of the calendar year. Wikeem (1984) identified two annual flushes of nutrient availability in a big sagebrush/bluebunch wheatgrass community on the Okanagan Game Farm. The initial, predominant flush occurred in March and April, with onset of spring growth of forbs and grasses. Nutrients available in fall regrowth occurred primarily within grasses, including bluebunch wheatgrass, cheatgrass, junegrass and needleandthread. August crude protein for regrowth of these first 2 grass species attained levels comparable with initial spring growth in April. Furthermore, crude protein for all 4 grasses declined less sharply from October to November than during the May to June period.

Woody plant plant species, which retain higher levels of crude protein, phosphorus and carotene than grass or forbs during winter (Cook 1972), are selected by sheep primarily during winter and early spring. Relatively low proportions of woody plants in bighorn sheep diets should not be considered indicative of unimportance, particularly if these species supplement more readily available, but perhaps lower quality grasses during winter.

An optimal variety of herbaceous and woody plant species certainly occurs within a mosaic of vegetation. Such a mosaic may likely consist of both climax and seral plant communities. Historical association of California bighorn sheep with steppe bunchgrass vegetation does not necessarily imply a primary preference for and/or dependence upon a few climax forage species. Rather, such historical association suggests evolutionary adaptation for utilization of the variety of forages, microsites, successional and climax plant communites normally and naturally available within steppe bunchgrass vegetation.

Carrying Capacity

The number of bighorn sheep which can be supported in the Ashnola region depends on the amount and distribution of food, shelter, and water in relation to the animal's mobility. Appropriate shelter, particularly that which is suitable for lambing purposes, may be an important limiting factor for the bighorn sheep population (Blood 1961). However, the capacity of existing lambing grounds has never been documented and consequently, cannot be quantitatively incorporated into the assessment of carrying capacity. Water availability is generally unlimiting to bighorn sheep and is further improved by the establishment of water troughs for livestock use. Thus, forage availability will be the primary consideration in the following discussion on carrying capacity.

Estimation of carrying capacity in the Ashnola region is extremely difficult even when forage availability is the only limiting factor considered. In most cases, problems in estimation arise because of inadequate information on factors governing carrying capacity. For instance, recent estimates of forage production on the various grassland communities in the Ashnola are unavailable. Production estimates have not been conducted in any of the grassland communities since 1972; in some communities, the latest available estimates were obtained in 1963. Range productivity has likely altered since that time because good cattle management has replaced historic overgrazing. Additionally, inter-yearly variations in forage production emphasizes the need for yield estimates based on long term measurements. Estimates of carrying capacity based on a single year's data may well be misleading if forage production for that year was fortuitously high or low.

The problem of estimating forage production is further compounded by the fact that the size, distribution and type of grassland communities occurring on the Ashnola ranges have likely changed since they were documented by Demarchi (1965). Although Harcombe and Kowall (1982) recently produced a vegetation landscape map for Flatiron Mountain, similar information does not exist for Crater Mountain.

Insufficient knowledge of bighorn sheep biology also contributes to the difficulty in estimating carrying capacity. Although South Slope has been identified as the most important winter range in the Ashnola (Blood 1963, Demarchi 1965), localized animal movement is not well documented for this range. Because bighorn sheep use is unlikely uniform over South Slope, it would be misleading to estimate carrying capacity on the basis of forage production over the entire slope. Alternatively, it is of interest to determine whether certain areas are unoccupied because of insufficient sheep numbers or because they represent undesirable habitat. Total areas utilized by bighorn sheep on other winter ranges are also not well documented. The difficulty of estimating total area useable to sheep is further aggravated by snowfall, which may affect animal mobility as well as accessibility of forage to sheep.

Another complication in estimating carrying capacity is introduced by the fact that total time spent by bighorn sheep on the winter range may vary from year to year. Additionally, Blood (1963) has indicated that winter range useage may differ between rams and ewe-yearling-lamb groups. Thus, the amount of forage needed to satisfy bighorn sheep requirements depend in part on bighorn sheep behavior, which as yet is not entirely understood.

The timing of sheep use is also an important consideration in estimating carrying capacity, as the amount of standing forage is changing continually, either because of increments due to growth or because of losses due to weathering processes. Forage reductions caused by weathering can be very significant. For example, Harper (1969) documented that forage availability on October 2nd, in ungrazed bluebunch wheatgrass, Kentucky bluegrass, and pinegrass communities, declined to only 65, 81, and 70% respectively of peak forage production attained on July 26, 1967. Weathering losses generally continued throughout the winter, such that by April 20, 1968, the bluebunch wheatgrass and Kentucky bluegrass communities provided only 35 and 18 percent respectively of peak forage production observed the previous summer. Similarly, Morrison reported that between October 9, 1968, and April 22, 1969, weathering caused available forage to decline by 41.8% and 16% respectively in a bluebunch wheatgrass and Kentucky bluegrass community. Weathering losses of this magnitude imply that forage availability to bighorn sheep will depend considerably on the season of animal use. Not only is the season of use by bighorn sheep likely to vary from year to year, but also the majority of forage yield estimates existing for Ashnola grassland communities represent single point estimates, and do not consider the dynamic nature of standing biomass.

Forage availability to bighorn sheep in the winter becomes even more difficult to estimate when grazing by bighorn or cattle takes place in the spring or summer. Depending on the season or intensity of defoliation, a grazed plant may or may not initiate a secondary crop of tillers. Thus, the yield of regrowth cannot be assumed simply to equal total annual production minus the grazed biomass. Currently, virtually all winter-spring ranges in the Ashnola region receive some form of grazing by either cattle or bighorn sheep in spring and/or summer.

Given the above difficulties, any estimate of carrying capacity based on existing knowledge can only be regarded as a crude approximation which is more valuable as an academic or illustrative exercise than a figure useful for management prescriptions. The following estimate of carrying capacity of South Slope must necessarily be regarded as such. The procedure and assumptions inherent in this estimate are enumerated:

1. Bighorn sheep consumption rate of poor quality forage equals 60g per kg of metabolic body weight per day (Agricultural Research Council 1980).
2. Mean body weight of a bighorn ewe equals 61.6 kg (Harper 1984).
3. Consumption rate per ewe is therefore 1.32 kg per day, or approximately 40 kg per 30 day month.
4. The occurrence of grassland communities on South Slope is assumed to follow the vegetation landscapes identified by Harcombe and Kowall (1982). On this basis, South Slope is composed of 50.1% bluebunch wheatgrass - Idano fescue communities, 46.9% bluebunch wheatgrass - junegrass communities, and 2.9% Kentucky bluegrass communities.
5. The most recent forage production estimates were used to calculate carrying capacity. Forage production equalled 1539 kg/ha for the bluebunch wheatgrass - Idaho fescue community and 1411 kg/ha for the

bluebunch wheatgrass - junegrass community (Demarchi 1973a). Production estimates for Kentucky bluegrass communities on South Slope are unavailable. Consequently, production values measured for this grassland type on Juniper Slope (1546 kg/ha) were used instead (Harper 1969). Mean forage production on South Slope therefore equals 1477 kg/ha.

6. Given that South Slope is equal to 249 ha (Demarchi 1965), the peak volume of standing biomass on this range equals 367,773 kg. Assuming that a 50% utilization standard represents a safe level of grazing intensity, the standing biomass available for consumption therefore equals 183,887 kg.
7. In order to account for weathering losses, it is assumed that 40% of forage will not be available to bighorn sheep. Thus, utilizable forage on South Slope equals 110,332 kg, which is equivalent to 2758 months of feed for a bighorn ewe.
8. Carrying capacity for bighorn sheep on South Slope is consequently equal to 460 ewes if this range is occupied by bighorn for a 6 month period, or equal to 345 ewes if occupied by the animals for an 8 month period.

The above estimate of carrying capacity far exceeds the actual number of bighorn sheep currently occupying South Slope. This suggests that forage availability is not a limiting factor to population growth in the Ashnola bighorn. It is stressed, however, that the above computation is seriously limited by the procedures and assumptions of the exercise. For instance, forage production estimates used in the calculation may not be altogether representative of current range productivity. Additionally, correction factors have not been used to account for the effects of snowfall, local physiography, or spring grazing on forage accessibility.

POPULATION DYNAMICS OF CALIFORNIA BIGHORN SHEEP IN THE ASHNOLA REGION

Population Estimates

Logistical difficulties in population censusing, combined with variations in sampling intensity, sampling period, sampling technique and observer experience, collectively limit precise establishment of population trends for sheep in the Ashnola region. Additionally, high neo-natal mortality complicates comparison with population estimates which include lambs.

Nonetheless, Blood (1961) summarized historical accounts that, prior to settlement by Europeans, the Ashnola region was "simply alive with sheep, and had been for so many years that they were forced to migrate." Excessive hunting during the late 1800's however, produced large declines in sheep numbers, such that counts by McTaggart-Cowan (In: Blood 1961) reported only 102 sheep on South Slope in December of 1950. A series of counts during the summer of 1960 indicated an increased population of at least 242 animals, with approximately 170 sheep wintering primarily on South Slope. Demarchi (1965) recorded similar estimates in 1963 (250 sheep) and 1964 (241 sheep), with an average of 172.5 and 73 sheep wintering on Flatiron and Crater Mountains respectively.

Scheffler (1972) reported a personal communication from Spalding, who also suggested that sheep populations increased after 1960, with definite counts of at least 311 sheep in 1967. Further knowledge of additional uncounted bands on Crater Mountain and along Paul Creek indicated that approximately 400 bighorn sheep occupied the Ashnola in 1967, with the Flatiron Mountain band containing 212 sheep by actual count (Hankins 1982).

Ramsay (1980) summarized unpublished sheep counts conducted by B.C. Fish & Wildlife personnel, which suggested a declining population on Flatiron Mountain between 1970 (168 animals) and 1975 (148 animals). Counts conducted by Ramsay (1980) indicated further declines to 131 sheep by 1980, although Harper (1983) reported higher populations of 180 and 182 bighorn sheep on Flatiron Mountain in 1982 and 1983 respectively.

The population numbers discussed above should be viewed as relative trends rather than absolute differences. For example unpublished field data collected by E. W. Taylor (In: Blood 1961) indicate a population of 122 animals in 1960, which is only approximately 50% of Sugden's (1961) estimate of 250 sheep in 1959 and Blood's (1961) estimate of 242 animals in 1961. Taylor's estimate is almost certainly low, and suggests that significant changes reported for sheep populations in the Ashnola region between the periods 1950-1960, 1960-1967, 1967-1980 and 1980-1982 may have resulted partially from differing sampling periods, intensities and techniques.

Conception and Recruitment Rates

Pregnancy testing of ewes captured during February and March of 1983 revealed that conception rates are not likely limiting recruitment of bighorn sheep in the Ashnola region, as all eleven tested ewes had conceived (Harper 1984). Although twinning was not detected in these animals, multiple births may occur, as Ramsay (1980) observed on several occasions a ewe suckling two lambs. Although Ramsay's (1980) observation does not provide irrefutable evidence of twinning in the Ashnola bighorn sheep, it does suggest a potential conception rate of over 100%. Indeed, autopsies of twelve ewes from the nearby Vaseaux sheep population revealed twinning in four animals, although Eccles and Shackleton (1979) believed that a significantly higher mortality rate existed for twins compared to single births.

Appendix H summarizes classification counts and recruitment rates for California bighorn sheep on South Slope between 1960 and 1983 (Blood 1961, Demarchi 1965, Scheffler 1972, Ramsay 1980, Harper 1984). Relatively high lamb/ewe ratios in 1960 (.60) and 1961 (.69) declined to .43, .42 and .46 in 1963, 1964 and 1967 respectively. Further declines continued between 1970 and 1983, as lamb/ewe ratios averaged 0.25, ranging between 13 and 47 lambs per 100 ewes.

Total numbers of mature ewes however, displayed slightly different trends from lamb/ewe ratios. Between 1960 and 1963, an average of 44.6 ewes were recorded on South Slope. Ewe numbers increased to 72 in 1964 and 107 in 1967, but declined by approximately 2 ewes per year between 1970 and 1980, to give an average of only 70.9 individuals during this decade (Harper 1984). Counts during 1981 and 1982 recorded 81 and 82 ewes respectively.

These demographic data indicate relative trends rather than absolute population levels. For example, Harper (1984) warned that an increase to 81 ewes in 1982 from only 53 in 1980 resulted partially from differences in survey technique or sheep distribution patterns, as observed lamb production during the period was insufficiently high to account for such large increases in adult females. Similarly, Ramsay (1980) noted that greater numbers of yearlings in 1979 and 1978 than lambs in 1978 and 1977 respectively, necessarily resulted from inaccurate census data. Nonetheless, population values in Appendix H suggest that lamb/ewe ratios have declined since 1967. Harper's (1984) observation of 100% pregnancy during the winter of 1982-1983 suggests that low recruitment rates likely resulted from mortality subsequent to birth. Indeed, Spalding (1973) documented that approximately 50% of lambs which survive the first 3-4 weeks of life succumbed during their first year.

Lawson and Johnson (1982) submitted that 50 lambs per 100 ewes is generally adequate for population growth in mountain sheep. This generalization does not always hold true, however, as the lamb/ewe ratio required to maintain a stable or increasing population is variable and depends on population structure as well as extrinsic factors governing population growth. For example, bighorn sheep on Wildhorse Island remained relatively stable between 1959 and 1962 despite a mean lamb/ewe ratio of 0.76 (Woodgerd 1964). Similarly, population growth was not apparent in the Ram Mountain bighorn sheep between 1971 and 1975, even though the mean lamb/ewe ratio for this period equalled 0.65 (Wishart 1976). In contrast, Bodie and Hickey (1980) found that bighorn sheep in Morgan Creek, Idaho, increased from 67 in 1973 to 111 in 1975 following a mean lamb/ewe ratio of only 0.40. Given the variation in population dynamics among bighorn sheep herds, population status of the Ashnola population is not readily identified from its lamb/ewe ratio.

It does not appear as though the lamb/ewe ratio for the Ashnola bighorn is substantially lower than that for a neighbouring population in the Vaseaux Lake area, B.C. Lamb-ewe counts, available between 1971 and 1980 for both the Ashnola and Vaseaux Lake bighorns, averaged 0.25 and 0.29 (B.C. Ministry of Environment, unpub. data) for the two respective sites. The actual difference between the two lamb/ewe ratios may be slightly higher than is apparent, however, as censusing was conducted primarily in spring and summer in the Ashnola, but not until late winter in the Vaseaux Lake area. Thus, lamb/ewe ratios reported for the Vaseaux Lake herd would reflect both early natal as well as winter mortality of lambs. Alternatively, biases introduced by different sampling periods may not be unduly serious, as winter mortality of lambs in the Ashnola has been relatively low in recent years (Harper 1984).

Lamb/ewe ratios in the late 1960's and early 1970's were somewhat higher for the Chilcotin River bighorn than for the Ashnola bighorn. Fall surveys between 1968 and 1971 revealed a mean lamb/ewe ratio of 0.41 for the Chilcotin River population (Demarchi and Mitchell 1973). Lamb/ewe ratios are unavailable for the Ashnola population in 1968 and 1969. However, the mean lamb/ewe ratio for the years 1967, 1970, and 1971 equalled 0.32 for the Ashnola bighorn.

Factors Affecting Mortality

Mortality may be caused by several factors, including inclement weather, predation, parasites and diseases, inadequate nutrition, hunting or accidents.

Weather

Demarchi (1965) observed that seasonal mortality of lambs on South Slope peaked between late November and mid-March for the years 1960-1961 and 1963-1964. Demarchi (1965) did not speculate on the cause of mortality during this winter season, but presumably, adverse climatic conditions may have contributed.

Ramsay (1980) assessed the impact of inclement weather on lamb mortality by developing linear regressions between winter severity indices and lamb/ewe ratios on South Slope between 1970 and 1980. He did not find any statistically significant relationships and concluded that within the range of winter severity observed between 1970 and 1980, inclement weather produced negligible effects upon lamb production rates.

Ramsay's (1980) analysis may have been somewhat misleading however, as his winter severity indices were based on climatological data recorded from January through April. Because the lambing season does not begin until late April, climatic regimes between January and March would not have had any direct effect on lamb mortality.

Harper concurred that an obvious correlation between inclement weather and neonatal mortality was lacking when he examined lamb survival in relation to climatological records for the lambing period in 1983. Of the three periods when lamb numbers declined noticeably, two occurred during and after periods of increasing temperature, declining humidity, and no precipitation. Although the third period of lamb mortality coincided with a rain storm, temperatures were not as extreme as those associated with two storms when lamb mortality was not apparent. Harper (1984) further noted that thermal stress is likely moderated by the extensive use of shelters and lower elevations which are characterized by milder microclimates and higher temperatures.

Demarchi and Mitchell (1973) observed a significant die-off of California bighorn sheep in the Chilcotin River area during the fall and winter of 1968-1969. Between August 2 and November 22 of 1968, ewe counts declined from 201 to 162 animals, while lamb counts declined from 81 to 37 animals. During this same period however, ram counts increased from 74 to 80 animals. Further reductions for all three animal classes occurred following persistent, unusual snow accumulation of .60 m (2 feet) in December and January, when rams declined from 80-49 animals, ewes from 162-140 animals and lambs from 37-35 animals. Similarly, Morrison (1972) also noted that a heavy snow pack during the winter of 1968-1969 reduced the number of bighorn sheep wintering on South Slope from 157 on December 15, to 52 in early January, declining still further to only 44 sheep by February 22. Most of the sheep leaving South Slope moved to Gillanders Creek and beyond (Morrison 1972). Presumably therefore, very severe winters, combined with lack of available grasslands free from accumulating snow, could produce relatively significant bighorn sheep mortality in the Ashnola.

Predation

Potential predators of California bighorn sheep in the Ashnola include cougar, bobcat, lynx, coyote, black bear and golden eagle (Spalding 1973, Ramsay 1980). Blood (1961) however, based upon lack of positive evidence, discounted predation as a serious limiting factor for bighorn sheep in the Ashnola Region. Ramsay (1980) collected five coyote and four black bear scats in 1978 and 1979, which failed to yield hair of either bighorn sheep or mule deer. Although Ramsey (1980) observed golden eagles swooping over the lambing cliffs between April and May in all 3 years of study, no successful predation was observed. Similarly, even though two cougars were observed feeding on a ram carcass in February 1977, cause of death was not clearly attributable to predation (Ramsay 1980).

In contrast to Blood (1961) and Ramsay (1980), Spalding (1973) concluded that predation of lambs seriously depressed recruitment rates in the Ashnola sheep population. On May 24, 1972, Spalding (1973) observed 65 ewes with 15 lambs. On the morning of May 26, ewes and lambs appeared apprehensive of a coyote which was stalking the sheep. An intensive sheep count on the afternoon of May 26 revealed 64 ewes with only 10 lambs. Moreover, the ewe/lamb groups had altered their normal grazing habits. Prior to this incident, ewes had begun gradually to graze their lambs on open grassland away from escape terrain. Following the presumed predation on the evening of May 25 however, only 1 ewe grazed with her lamb on open grassland, while the remaining ewes left their lambs in escape terrain during periods of feeding in open grassland. As further circumstantial evidence of significant predation, Spalding (1973) cites the very large differences in conception rates of California bighorn sheep in captivity (97 lambs/100 ewes), and the average "drop rate" observed in the Ashnola of approximately 25 lambs/100 ewes.

Harper (1984) provided additional circumstantial evidence of coyote predation, as 47% of all examined scats contained hair and bone fragments of bighorn sheep. Furthermore, Harper (1984) tagged 11 pregnant ewes on Flatiron Mountain, 10 of which produced lambs. Five ewes gave birth on the lambing cliffs adjacent to South Slope, while the remaining five ewes gave birth at unknown locations. Of the five ewes on the lambing cliffs, only 2 produced lambs which survived until August. The remaining three lambs suffered mortality between 5 and 21 days of age. Similarly, only 2 of the 5 ewes which left South Slope returned with lambs. Based upon the dates of departure and return, Harper (1984) conjectured that lamb mortality occurred at less than 20 days of age. Ewes which lost lambs returned to South Slope between May 10 and May 20, while those ewes with surviving lambs returned in early July. Three periods of lamb reductions were identified, including April 20-30, May 12-18 and May 26-June 6 (Harper 1984).

Although these observations do not clearly identify predation as the source of lamb loss, Harper (1984) supports Spalding's (1973) conclusion of predation as a likely cause, particularly as lamb reductions did not coincide with inclement weather in 1983 (Harper 1984). Such circumstantial evidence certainly suggests that predation may be serving to stabilize or depress current levels of recruitment rates in the Ashnola bighorn sheep population.

Although predator control programs in the 1950's and 1973 failed to enhance bighorn sheep recruitment, this may have been caused by incomplete eradication of predators (Ministry of Environment field notes). Additionally, lamb production may have been depressed by unusually severe climatic conditions during the late winter and early spring of 1973 (Webster, pers. com.).

Parasites and Diseases

Blood (1961, 1963b) reported that Protrostrongylin lungworm larvae infested 80% of the Ashnola California bighorn sheep population in 1960, as determined from examining 101 pellet groups. Little variation of infestation occurred among yearling, ewe and ram groups, although only 54% of lambs were infected with lungworm larvae. Autopsies on two adult sheep, combined with fecal examination, revealed 8 nematode and two tick species, plus one coccidium.

Ramsay (1980) reported an apparent decline of lungworm infestation by 1978 and 1979, when adult ewes, yearlings and lambs supported average infestations of 50.7 55.2 and 0 percent infestation respectively. Such apparent reduction in parasite loading between 1960 and 1978-1979 however, may have resulted because of seasonal differences in sampling date. Ramsay (1980) determined infestation between April and June, a period of relatively low lungworm parasitism, while Blood (1961) sampled throughout the period of May 1960-June 1961. Such seasonal variability of infestation is most evident in lambs, which are generally free of lungworm parasites until approximately 2 months of age (Blood 1961).

Harper (1984) analysed blood serum collected from 6 adult ewes on South Slope in 1983. Results proved negative for *Brucella abortus* and *Leptospira* antibodies. Analysis of nasal swabs indicated 30-50 percent infestation for 3 non-pathogenic bacteria: *Flavobacter,* non-hemolytic *Corynebacterium spp.* and alpha- *Streptococcus.* Two of 6 nasal swabs isolated hemolytic *Staphylococcus aureus,* a potentially pathogenic bacterium. All 12 nasal swabs proved negative for *Pasteurella,* while 50% of ewes were infested with *parainfluensa* type-3 virus.

Despite such infestations, particularly of *Protrostrongylin* lungworm, Blood (1961, 1963b) and Ramsay (1980) both concluded that California bighorn sheep herds in the Ashnola do not suffer significant chronic mortality due to disease or parasites. Rather, Blood (1961, 1963b) hypothesized that high infestation rates perhaps acted as population depressants, with mortality surfacing under stress from long periods of inclement weather and poor nutrition. Similarly, Ramsay (1980) concluded that the ubiquity of lungworm infestation found in virtually all bighorn sheep populations, combined with relatively low levels observed in the Ashnola, suggested that physical condition of ewes, and subsequent lamb/ewe ratios, were not likely seriously reduced by lungworm larvae.

The timing of lambing losses also indicate that lungworm infestation is an unlikely cause of low lamb/ewe ratios. According to Spraker and Hibler (1982), transplacental transmission of heavy lungworm burdens with maturation of the parasites when the lambs are 3.5 to 4.5 weeks of age appears to be the most important predisposing factor for pneumonia-lungworm induced mortality in lambs. Woodard et al (1974) and Horesji (1976) also reported that lamb mortality attributable to the lungworm-pneumonia complex generally occurred in lambs one to four months old. In contrast, mortality of lambs belonging to ewes tagged by Harper (1984) all occurred within three weeks of parturition.

Population response to the antihelminthic drug program conducted during the winters of 1978-1980 is difficult to assess. Although lamb/ewe ratios increased from .16 in 1977 to .47, .34 and.32 in 1978, 1979 and 1980 respectively, such results due to drug treatments are confounded with simultaneous winter feeding and mineral supplementation. Relatively mild winters during 1977-1980 may also have contributed to increased lamb/ewe ratios, which declined to near pre-treatment levels following an initial year of substantial increase.

Nutritional Deficits

Demarchi (1965) and Harper (1969) both demonstrated that quality of forage on winter ranges of Flatiron Mountain generally fell below maintenance requirements of grazing ungulates. Feeding programs initiated during the winter of 1977-1978 apparently offset such presumed nutritional deficits, as Ramsay (1980) reported lamb/ewe ratios of .47 in 1978 compared to only .16 the previous year when no winter feeding occurred.

Harper (1984) however, observed no conclusive signs of nutritional stress when he measured body weights, fat deposits and blood serum mineral status of ewes in late gestation during the winter of 1982-1983. Rather, mean live weights of 10 adult ewes equalled 61.6 kg (135.8 lbs) during February and March, higher than would be expected assuming nutritional deficiencies. Identical mean live weights were recorded for 17 adult females sampled from the Vaseux Lake herd in March of 1984. In contrast, liveweights of adult ewes at the Okanagan Game Farm study site averaged only 46.8 kg (103.2 lbs). Despite these low body weights however, lamb production and survival in the experimental sheep herd equalled 64 and 82 percent in 1982 and 1983 respectively, substantially higher than the 28 and 25 percent observed in the Flatiron Mountain population (Harper 1984).

Similarly, average body condition scores (2.3) indicated adequate fat stores, while energy, iodine, calcium, magnesium and phosphorus during mid-winter all appeared normal, compared to domestic sheep requirements. Only serum levels of copper, zinc and selenium slipped to levels considered marginally deficient for domestic sheep, although tissue levels of copper and zinc appeared adequate (Harper 1984). Selenium deficiencies commonly occur throughout British Columbia bunchgrass ranges, with deficient domestic calves rarely surviving more than one or two weeks. Similar bighorn sheep lamb mortality due to selenium deficiencies however, have never been documented or implicated in published literature.

Accidents

Blood (1961) and Sugden (1961) both noted that accidental deaths occur in every animal population. Sugden (1961) described a 9 month old bighorn sheep lamb that had fallen from an icy, precipitous cliff, and sustained fractures of the skull, mandibles and 3 lumbar vertebrae.

Blood (1961) reported only 2 accidental sheep deaths in the Ashnola between 1960 and 1961. A yearling discovered on South Slope died of malnutrition symptoms, apparently precipitated by a fractured left humerous. No signs of predation existed, although Sugden (1961) indicated that injured animals are certainly more vulnerable to predation. Generally however, accidental death, including that resulting from drownings during migration (Sugden 1961), unlikely limits population growth of bighorn sheep in the Ashnola.

Hunting

Blood (1961) reported unrestricted hunting as one of the principal factors reducing bighorn sheep numbers in the Ashnola in the late 1800's. Consequently, the hunting season was closed between January 10 to September 10 beginning in 1887, and was eliminated completely between 1909 and 1954, with the exception of a 3-day hunting period in 1947. Starting in 1955, 3- to 4-day hunting seasons in September permited bag limits of 1 ram displaying at least a three-quarter horn curl.

Bighorn sheep numbers increased only slightly during the periods of hunting prohibition and regulation, which prompted Blood (1961) to conclude that hunting pressures do not impose limits to population growth in the Ashnola. Blood (1961) reported that herd structures of 1960 permitted approximately 13 trophy rams five years of age and older to be harvested annually. Between 1947 and 1960, 63 rams were harvested, with annual kills ranging between 4 and 14. The mean annual harvest of 9 rams was well within the upper limit of 13 animals, although the average age of ram harvested declined from 7.0 to 5.1 years. This suggests that potential changes in population structure may have resulted from hunting.

Hankins (1982) summarized bighorn sheep harvests from 1975 and 1981, when hunting by permit only occurred in designated zones within the Ashnola between August 25-September 21. Total number of permits allocated varied between 12 and 28, while harvested animals ranged between 2 and 10. Numbers of harvested sheep did not correlate directly with hunting pressure, as assessed by total permit numbers. Unpublished Fish & Wildlife data indicate 11 and 9 bighorn sheep were harvested in 1982 and 1983 respectively.

Two sheep harvested in 1975 were 6 and 8 years old respectively. Average age of 9 animals taken in 1983 equalled 4.0, with a range from 1 to 9 years of age. However, no obvious trend in age structure of the sheep herd is indicated by such average ages, as 10 animals taken in 1981 ranged from 3 to ten years of age, with a mean of 7.8 years. Therefore, the warning of altered age structure due to hunting, voiced by Blood in 1961, has not yet obviously materialized.

Sugden (1961) reported that documented illegal hunting west of the Fraser River between 1952 and 1959 accounted for approximately 20% of the legal harvest during this same period. Poaching in the Ashnola likely removes a smaller proportion of the legal harvest because of greater opportunity for control of hunters. Consequently, current hunting pressure, both legal and illegal, apparently remains within sustainable levels.

Summary

Mortality rates due to inclement weather and accidents are negligible, and impose no significant limits to growth of California bighorn sheep populations in the Ashnola. Recently documented high conception rates similarly fail to explain low recruitment rates. Moreover, poaching plus controlled hunting of trophy rams likely both remain within sustainable population levels. Lungworm infestation exists throughout the Ashnola sheep herds, but no documented evidence or suggestions of lungworm induced die-offs for California bighorn sheep exist in the literature.

Winter feeding has coincided with temporarily increased recruitment rates, although nutritional status of ewes remained relatively high in 1982 and 1983 when low lamb/ewe ratios persisted. In contrast, strong circumstantial evidence suggests that predation of sheep during the first year of life may remove significantly high proportions of lambs.

Undoubtedly, population growth responds to all these factors affecting recruitment. The specific contribution(s) of each factor are difficult to identify, and may even vary among years. Search for a single factor limiting recruitment rates will unlikely explain fully the complexity of population dynamics. Nonetheless, coyote predation offers the single factor most likely limiting current recruitment rates and population growth of California bighorn sheep in the Ashnola region.

ECOLOGICAL RELATIONSHIPS BETWEEN CATTLE AND WILDLIFE

Behavioral Interaction Between Sheep and Cattle

Hankins (1982) summarized published concerns that "sheep have a well documented aversion to cattle." Such concerns usually are based upon observed displacement of sheep from traditional ranges following introduction of cattle, or reoccupation of habitats by sheep subsequent to cessation of long-term cattle grazing. Such interactions are presumed to be behavioral response to limits in space rather than food, cover or water (Trefethen 1975). Usually however, only circumstantial, correlative data are provided. Such personal observations further convinced Hankins (1982) that cattle and California bighorn sheep do not mix, although sheep feeding occasionally occurred on areas recently grazed and vacated by cattle.

Alternatively, Sugden (1961) observed bighorn sheep grazing within a few meters (yards) of both cattle and horses, with no special reaction from either of the animal species. Nonetheless, Sugden (1961) also reported anecdotal information for the Churn Creek herd that bighorn sheep did not utilize a traditional wintering area in 1906, most likely because of the new presence of cattle during the winter period.

Blood (1961) summarized distributional overlap of cattle and sheep in 1960, and reported that 70% of bighorn sheep winter/spring ranges were grazed by cattle, while less than 25% of sheep summer ranges received cattle use. Blood (1961) therefore concluded that competition between these two ungulates most likely centred upon spring and fall utilization by cattle of sheep winter/spring ranges.

Current cattle distribution and rotations likely reduce the degree of overlap noted by Blood (1961). On Flatiron Mountain, 100 livestock graze Flatiron and Starvation Flats from June 1-June 21, and Juniper Slope between June 22-July 15 (Appendix C). Bighorn sheep during these periods primarily utilize South Slope, although frequent spring use of Juniper Slope was reported by Blood (1961). Juniper Slope also provided fall forage for approximately 50% of ewe/yearling/lamb groups in 1983 (Harper 1983). Excessive snow accumulation on Juniper Slope prevents winter use by bighorn sheep, which overwinter primarily on South Slope, where cattle grazing no longer occurs.

Distributional overlap between livestock and sheep may also occur on summer ranges of Flatiron Mountain. Cattle graze Observation Flat and Joe Lake Alpine range units between July 16-July 31, and August 1-September 15 respectively (Appendix C), areas simultaneously utilized by sheep following spring migration.

Similar cattle rotations occur on Crater Mountain; presumably, this produces similar kinds of distributional overlap with bighorn sheep. Such overlap may be more intense than on Flatiron Mountain, as no winter ranges have been reserved exclusively for sheep use. Nonetheless, no published or anecdotal information exists which suggests serious behavioral or distributional overlap between cattle and bighorn sheep on winter ranges of Crater Mountain.

Although distributional overlap between bighorn sheep and cattle exists within broad geographic areas, spatial segregation between animal species reduces direct competition. For example, Demarchi (1965) documented primary sheep use of spring bunchgrass slopes exceeding 25 degrees, while cattle use declined sharply on slopes greater than 15-20 degrees. Such habitat segregation persisted on summer ranges, where cattle utilized timber fringes and meadows, while sheep inhabited alpine slopes and ridges (Demarchi 1965).

Blood (1961) noted similar patterns of cattle and sheep distribution, as cattle fecal groups equalled 2333, 420 and 119 per hectare (940 170 and 48 per acre) on slopes 0-15, 15-30 and > 30 percent respectively. In contrast, bighorn sheep pellet groups peaked at intermediate slopes, averaging 605, 1334 and 1112 (245, 540 and 450 per acre). Forage utilization by cattle also corresponded primarily with slopes < 15 degrees, prompting Blood (1961) to conclude that intense competition between bighorn sheep and cattle existed on only a small part of South Slope in 1960.

Sugden (1961) similarly observed that bighorn sheep and cattle tended to segregate themselves on the basis of slope. It remains uncertain however, whether selective use of steep slopes by sheep in regions grazed by cattle is due to apparent preference for these habitats, or avoidance of cattle grazing on more level terrain.

Blood (1961, 1963a) reported that rutting activity peaked between mid- and late November, with earliest rutting behavior noted on October 13. Rutting on Flatiron Mountain occurs primarily on South and Juniper Slopes. Livestock are excluded from South Slope, and have departed Juniper Slope by July 15, thereby offering no interference with rutting. Livestock remain in Hargreaves Pasture on Crater Mountain only until October 31. Consequently, interference with peak rutting activity recorded by Blood (1961) likely does not occur. Although early rutting activity may be altered by the presence of cattle in Hargreaves Pasture, no published information exists to either confirm or refute such interference.

Behavioral interactions and seasonal distributional overlap certainly exist between cattle and California bighorn sheep in the Ashnola region. The current intensity of subsequent competition is likely less than prior to 1968 because of improved livestock control, plus reservation of South Slope for exclusive sheep use. Despite some legitimate claims of localized behavioral antagonism between bighorn sheep and cattle in other regions of North America, these two species can coexist within broad geographic areas. Coexistence may be enhanced by behavioral and/or genetic preference for different terrain gradients. Although behavioral antagonism may deter sheep from areas being grazed by cattle, these two animal species have been observed occasionally to feed and water in close proximity on Crater and Flatiron Mountains.

Livestock grazing has occurred in the Ashnola since the 1880's. Historically, this livestock use has been uncontrolled with resultant overgrazing. Nonetheless, bighorn sheep persisted. Such empirical evidence suggests that California bighorn sheep and cattle are able to coexist in the Ashnola, behavioral preferences notwithstanding.

Behavioral Interaction Between Sheep and Mule Deer

Historical numbers of mule deer in the Ashnola region likely exceeded present populations. Morrison (1972) reported personal communications of between 200 and 300 mule deer observed on South Slope on one day in 1916. Morrison (1972) quoted estimates of approximately 1800-2500 mule deer distributed throughout the Ashnola region in 1972.

Sugden (1961) observed common associations between mule deer and California bighorn sheep on Sheeps Flat, which is utilized as winter and spring ranges by the Churn Creek sheep herd. On many occasions deer fed directly with bighorn sheep on open grassland. In Big Basin however, an alternative winter range of the Churn Creek sheep poulation, mule deer primarily utilized habitats characterized by Douglas-fir, trembling aspen and lodgepole pine. Exposed grassland slopes appeared to be of little importance to mule deer during the winter.

Distributional overlap of mule deer and California bighorn sheep in the Ashnola occurs primarily between April and June, when herbaceous growth is succulent and plentiful (Blood 1961, Scheffler 1972). Deer seldom remained on sheep winter/spring ranges after late June, and were rarely observed in the centre of open grassland slopes during winter (Blood 1961). During summer and early fall, deer and sheep both moved to subalpine/alpine ranges, only occasionally descending to lower slopes (Scheffler 1972).

Morrison (1972) similarly reported that distributional overlap between mule deer and bighorn sheep peaked in spring. However, differential selection of habitats by deer and sheep reduced potential competition between these two animal species during spring. Although mule deer utilized a variety of habitats, including steep slopes apparently preferred by bighorn sheep (Blood 1961, Demarchi 1965), habitats most commonly utilized included forests, shrub communities and tree margins (Blood 1961, Morrison 1972). Demarchi (1965) demonstrated that spatial segregation also occurred within grassland habitats, as deer utilized seral plant communites 3 times more frequently than climax grassland communities. In direct contrast, bighorn sheep frequented climax communities 3 times more commonly than seral grassland communities (Demarchi 1965).

These results, combined with historically large populations of both mule deer and California bighorn sheep in the Ashnola region, suggest that bighorn sheep populations are not likely limited by behavioral interactions with mule deer. Concentrated distributional overlap occurs for only three months during spring, with competition mitigated by differing habitat preferences.

Behavioral Interaction Between Cattle and Mule Deer

Morrison (1972) provided the most detailed assessment of mule deer distribution and habitat selection in the Ashnola, and concluded that cattle grazing on bunchgrass winter/spring ranges during spring, when mule deer were still present, could produce competition for forage between these two animal species, particularly on Juniper Slope and Starvation Flats. Demarchi (1965) similarly showed that mule deer utilized open grasslands from late winter to early spring. Moreover, mule deer and cattle both demonstrated preference for seral grassland communities, as assessed by pellet group distribution (Demarchi 1965). Overlap between cattle and mule deer declined during summer and fall, when deer preferred shrub communities, tree margins and lodgepole pine forests at higher elevations (Demarchi 1965, Morrison 1972).

Cattle currently graze on Starvation Flats and Juniper Slope between June

1 and July 1, when deer are likely still present. Similarly, cattle and mule deer likely graze simultaneously on spring bunchgrass ranges of Crater Mountain between May 15 and the end of June (Appendix C). However, Morrison (1972) provided no indication of any behavioral antagonism of mule deer toward livestock. Indeed, no published reports exist of negative behavioral interactions in the Ashnola, while personnel interviewed indicated that mule deer and cattle often grazed in close proximity during spring, without any apparent antagonism.

Research on big sagebrush/bunchgrass ranges near Kamloops indicates that cattle grazing may even promote mule deer utilization the following spring. Although Willms et al. (1979) observed that potential for competition between mule deer and cattle was highest during spring, these authors also documented that moderate or heavy fall grazing by cattle increased deer utilization the following spring, as assessed by fecal group distribution. Willms et al. (1979) hypothesized that heavy fall utilization by cattle reduced bunchgrass stubble height, which created greater availability of spring growth. Light fall grazing by cattle produced no measurable increase in deer utilization the following spring.

Scheffler (1972) indicated that extensive overlap between mule deer and cattle existed throughout Flatiron and Crater Mountains. Direct behavioral interaction however, even during spring when overlap peaks, appears negligible.

Diet Overlap Between Sheep and Cattle

Optimal range management requires information regarding feeding habits and preferences of all grazing species utilizing specific management units. Such feeding habits and preferences for California bighorn sheep have been detailed in a previous section. Grasses generally constitute high proportions of sheep diet, particularly during fall (Wikeem 1984), winter and spring (Blood 1961, Demarchi 1965, Morrison 1972). Forbs comprise relatively low proportions of total diet (Blood 1961, Demarchi 1965, Morrison 1972), reaching peak use during spring and summer (Wikeem 1984). Woody plant species contribute minor proportions to sheep diet in the Ashnola throughout most of the year (Blood 1961).

Highly preferred forages during summer, as determined by comparison to availability, include smaller herbaceous plants such as nodding onion, timber milkvetch, wild buckwheat, silky lupine and Sandberg's bluegrass. Sheep exhibit intermediate forage preference for Idaho fescue and junegrass, while bluebunch wheatgrass provides low forage preference relative to other plant species ingested by sheep (Morrison 1972). Kentucky bluegrass also likely constitutes a preferred forage during spring and early summer, as suggested by botanical changes presumably induced by bighorn sheep grazing (Harper 1983). Pasture sage becomes highly preferred during early winter (Blood 1961, Sugden 1961, Morrison 1972, Wikeem 1984), and may even contribute significant proportions to total diet during this period (Blood 1961).

Morrison (1972) investigated June cattle diets on Juniper Slope based upon contents of two rumens, which indicated 97.5% selection for grasses.

Proportion by weight for forbs and woody plant species equalled only 1.7 and 0.8 percent respectively. No information regarding specific grass species was provided. Nonetheless, historical accounts, plus comparison of vegetation both inside and outside grazing exclosures, indicate high cattle preference for bluebunch wheatgrass, Columbia needlegrass and Idaho fescue. Alternatively, plant species of lower stature, such as Kentucky bluegrass, junegrass, Sandberg's bluegrass and pasture sage, are less preferred by cattle.

Holechek et al. (1982) provided more detailed information regarding diet of cattle on grassland vegetation in Oregon dominated by bluebunch wheatgrass, Sandberg's bluegrass and Idaho fescue. Data based upon 4 esophageally fistulated cows, plus 4 fecal collecter steers, were gathered during spring, summer and fall between 1976 and 1978.

Grasses comprised the largest proportion of cattle diets, ranging from a low of 54% in spring (June 20-July 18) of 1978, to a high of 91% during the fall (September 13-October 10) of 1977. Eighteen grass species were ingested, dominated by Idaho fescue (29%) and bluebunch wheatgrass (28%). Sandberg's bluegrass averaged 8% of cattle diet, occurring most frequently during summer (15.5%) and fall (14%) of 1978, when summer rains initiated considerable regrowth of this forage species.

Cattle diets generally shifted from forbs to grasses as the grazing season advanced from spring to summer. Although no preference indices were provided, Holechek et al. (1982) believed that cattle preferred forbs relative to grasses in early spring, particularly yarrow, balsamroot and wild buckwheat. During the 3 years of study, proportion of forbs in spring cattle diets ranged from 16 to 41 percent, but averaged only 5.3% during fall. Snowberry was the only woody species contributing measurable amounts to cattle diets, providing approximately 6% throughout spring, summer and fall.

Willms et al. (1979) utilized two rumen fistulated cows to study spring and fall diet selection in bunchgrass vegetation near Kamloops. Grasses dominated cattle diets during spring (95.0%) and fall (91.9%), consisting primarily of bluebunch wheatgrass (41%), needleandthread (25%) and crested wheatgrass (23%). Pasture sage and rose were ingested in both seasons, while bassia constituted the most commonly grazed forb during fall. No forage preference indices were provided.

These results indicate clearly that dietary overlap exists between cattle and California bighorn sheep. Both animal species rely heavily upon grasses during all seasons for the bulk of their respective diets. Similarly, forbs are selected preferentially by both animal species, primarily during spring availability.

Relative forage preferences of cattle and bighorn sheep differ for some forage species. Cattle select preferentially for bluebunch wheatgrass, while sheep do not. Alternatively, sheep select preferentially for pasture sage and Kentucky bluegrass on a seasonal basis, while cattle apparently depend upon these two plant species less heavily. Other examples of forage preference differences also exist. Nonetheless, such differences are relative rather than absolute, and do not indicate rigid diet segregation between bighorn sheep and cattle. Both animal species graze most herbaceous forages, usually in relative proportion to availability and/or stage of plant maturity (Holechek et al. 1982, Wikeem 1984). Cattle and California bighorn sheep generally depend upon the same plant species, whether assessed by proportion of diet or forage preference indices.

Diet Overlap Between Sheep and Mule Deer

Morrison (1972) assessed feeding habits of mule deer on Flatiron Mountain during fall, winter and spring based upon 3, 8 and 11 rumen samples respectively. Browse comprised the major portion of mule deer diets during fall (59.6%), winter (66.8%) and spring (53.8%), while forb consumption declined throughout these seasons, equalling 23.4, 19.7 and 7.7 percent in fall (October-November), winter (December-February) and spring (February-June) respectively. Peak grass consumption occurred in spring (38.0%), declining successively through the fall (17.0%) and winter (12.9%) periods.

Douglas-fir comprised the major browse species consumed during both winter (52.9%) and spring (43.2%), while lodgepole pine (22.8%), kinnikinnick (14.0%) and big sagebrush (12.3%) contributed the largest proportions of total diet in fall. Spring provided the greatest variety of forbs, as 16 different species each contributed 1.2% or less to total diet. Silky lupine and pussytoes equalled 6.4 and 7.8 percent of fall and winter diets respectively. Specific grass species grazed were not identified, although fall selection corresponded with succulent regrowth following fall rains (Morrison 1972).

Morrison (1972) developed mule deer forage preference indices during spring based upon grazed stem counts. In a Kentucky bluegrass community on Juniper Slope, western wheatgrass and junegrass were the most preferred grass species. Although Kentucky bluegrass was grazed more frequently (57.9%) than any other forage plant, this species ranked last in terms of forage preference among those plants grazed. Forbs, which were available in low amounts, generally showed high forage preference indices, particularly rock cress.

Similar results were obtained in a pasture sage community on Juniper Slope, where forbs, particularly nodding onion and rock cress, displayed the highest forage preference indices. Western wheatgrass, Kentucky bluegrass, needlegrass, Idaho fescue and Sandberg's bluegrass all provided relatively equal intermediate forage preference indices, while pasture sage ranked last among grazed plant species.

Other research in British Columbia generally supports Morrison's (1972) observations regarding mule deer foraging patterns. Sugden (1961) reported diets consisting of 90.0% browse, 5.0% forbs and 4.7% grass for mule deer wintering on Sheep Flats of Churn Creek. Pasture sage (63.1%) constituted the single most important winter forage at this site, while Douglas-fir and kinnikinnick were the most commonly utilized winter forages at Big Basin.

Willms et al. (1979) investigated rumen contents of mule deer grazing on ranges near Kamloops, and reported diets dominated by browse, increasing from 57.5 to 83.7 percent between September 15 and March 15. Grasses comprised less than 3.1% of rumen contents throughout this same period, but dominated spring (March 16-April 30) diets at 64.0% of rumen contents. Depending upon availability and phenology of grass species during spring, bluebunch wheatgrass, Sandberg's bluegrass, cheatgrass and junegrass alternatively provided preferred and/or important diet constituents (Willms and McLean 1978, Willms et al. 1979).

Based upon these results, potential dietary overlap between mule deer and

California bighorn sheep occurs most during spring when both animal species may be grazing new growth of grasses and forbs preferentially. Although both ungulates likely select similar grass species, including bluebunch wheatgrass, Idaho fescue and Kentucky bluegrass, Morrison (1972) believed that competition between sheep and mule deer on Flatiron Mountain remained relatively insignificant. Mule deer consumed herbaceous plants during only portions of their daily foraging activities, while browse still constituted the most important component of spring diets. In contrast, browse contributed a minor portion to bighorn sheep diet throughout the year (Blood 1961, Morrison 1972), equalling only 2.1% in spring (Morrison 1972).

Utilization of pasture sage by mule deer during winter also overlaps with coincident bighorn sheep preference for this plant species. However, deleterious competition has never been reported, and likely rarely occurs except on localized sites, for short periods of time, in response to unusually high concentrations of both animal species during winter.

Dietary overlap between bighorn sheep and mule deer occurs only seasonally, and does not include primary forage species common to both ungulates. Forage competition with mule deer therefore poses no serious limitation to population growth of California bighorn sheep in the Ashnola.

Diet Overlap Between Cattle and Mule Deer

As summarized previously, cattle foraging habits are similar to those of bighorn sheep. Grasses comprise substantial portions of the diet throughout the year, with forbs grazed preferentially during spring.

In contrast, mule deer diets consist primarily of browse, with preferential selection of some grasses and forbs during relatively short periods in spring and fall. Morrison (1972) speculated that cattle grazing on winter/spring ranges of Juniper Slope and Starvation Flats could reduce forbs available for consumption by mule deer. However, no data exist either to confirm or refute such competition between cattle and mule deer. In contrast, Willms et al. (1979) provided data which suggest that grazing by cattle removed mature foliage of grasses, thereby increasing the availability of grasses preferred by mule deer the following spring.

Dietary overlap between cattle and mule deer in the Ashnola occurs primarily during spring, but does not include major forage plants common to both animal species. Moreover, no data or anecdotal descriptions indicate or even suggest significant competition for forage between cattle and mule deer in the Ashnola. Such competition is therefore likely negligible, and poses no immediate concern regarding availability of forage for either cattle or mule deer.

Transmission of Parasites and Disease Between Cattle and Sheep

Appendix I lists parasites and diseases verified in California bighorn sheep populations of British Columbia (McTaggart-Cowan 1951, In: Blood 1961, Blood 1961, Blood 1963b, Sugden 1961, Harper 1984). Nine of these parasites have also been isolated from cattle in British Columbia (Gilchrist, pers. comm.), therefore offering a potential source of transmission to bighorn sheep. These parasites, which include broad tapeworm, thick-necked bladderworm, ruminant whipworm, winter tick, paralysis tick (Rocky Mountain wood tick) and spinose ear tick, are not endemic to cattle in British Columbia however, such that transmission may be considered relatively uncommon.

Alternatively, cattle in British Columbia frequently serve as hosts for coccidia (*Eimeria bovis* & *E. zurnii*) and nematodes (*Nematodirus spathiger*) . However, neither the *Eimeria* coccidium nor the *Nematodirus* nematode found in bighorn sheep by Blood (1961, 1963b) was identified to species, and therefore may not correspond to species hosted by cattle. Moreover, only one oocyst of *Eimeria* was reported by Blood (1961, 1963b), indicating that this coccidium does not likely present a serious infestation of California bighorn sheep.

Of those parasites verified to species in California bighorn sheep (Appendix I), only the abomasal worm *Ostertagia ostertagi* frequently occurs within cattle in British Columbia. However, this parasite also commonly infects mule deer (Blood 1961), suggesting that both cattle and mule deer may transmit *Ostertagia ostertagi* to bighorn sheep. Regardless of origin however, infestation of sheep by *Ostertagia ostertagi* appears quite low, as Blood (1961, 1963b) isolated only 1 specimen.

Bovine viral diarrhea, infectious bovine *rhinotracheitis* and *Brucella* spp. all afflict domestic cattle, with potential transmission to bighorn sheep. Harper (1984) however, showed negative results for these three diseases in tests of bighorn sheep ewes on Flatiron Mountain in 1983. Cattle are routinely treated for such diseases, plus parasites, thereby limiting the opportunity for transmission to bighorn sheep.

Indeed, no evidence exists that California bighorn sheep have ever contracted acutely serious diseases or pests from domestic cattle in British Columbia. Moreover, Blood (1961) noted that epidemic die-offs, common among Rocky Mountain bighorn sheep, are virtually absent among California bighorn sheep populations. Although transmission of disease and parasites between cattle and bighorn sheep in the Ashnola may exist, such exchange is minor, and apparently offers no chronic or acute limits to the health or reproductive vigor of either animal species.

Impact of Cattle Management on California Bighorn Sheep Habitat

Approximately 400-600 cattle grazed on Flatiron and Crater Mountains from 1914 to 1951. Accurate estimates of cattle numbers prior to 1914 are unavailable (Blood 1961, Morrison 1972). Domestic sheep numbers peaked at 1000 animals for seven grazing seasons between 1913 and 1923, with reduced bands of sheep periodically utilizing the Ashnola until the 1950's (Morrison

1972).

Cattle numbers declined to 150 in 1952 (Blood 1961, Morrison 1972). Upward revision of estimated carrying capacity however, prompted increases to 300 cattle in 1955, followed by an additional increase to 340 in 1957 (Blood 1961). Livestock numbers then remained relatively constant until 1968, at which time cattle were removed entirely from Crater and Flatiron Mountains (Blood 1961, Demarchi 1965, Morrison 1972). Approximately 400 cattle currently utilize the Ashnola, subsequent to resumption of livestock grazing in 1977.

Prior to 1968, official livestock numbers often underestimated actual livestock use (Quaedflieg, pers. comm.), which was usually uncontrolled and continuous during the spring, summer and fall periods. Domestic sheep grazing was particularly severe and many grassland ranges of the Ashnola were reduced to such annual weeds as stinkweed or peppergrass (Brink, pers. comm.).

Much of the bighorn sheep research in the Ashnola has focused on such botanical changes, including declines in preferred plant species and reductions in total forage available for bighorn sheep due to cattle overgrazing (Blood 1961, Demarchi 1965, Harper 1969, Morrison 1972, Scheffler 1972, Demarchi 1973a). Blood (1961) however, reported that only 20% of South Slope had been grazed by cattle to proper use or beyond during the summer of 1960. Indeed, average summer forage utilization by cattle, as determined by comparisons of grazed and ungrazed vegetation at 10 exclosure sites, equalled only 34% on Crater Mountain, Juniper Slope and South Slope. At two sites on South Slope, overwinter bighorn sheep use equalled 37% of forage available in October. Based upon these data, Blood (1961) concluded that sufficient carryover remained on South Slope in 1960 to support the sheep population throughout the winter. Blood (1961) cautioned however, that such conclusions assumed those grazing practices and stocking rates which existed in 1960. For example, if cattle had grazed South Slope for 6 weeks rather than 3, insufficient forage would remain to support bighorn sheep for the usual 6 month winter period (Blood 1961).

Demarchi (1965) documented the consequences of a heavier stocking rate, which increased from only 115 AUMS in 1960 at the time of Blood's (1961) study to approximately 225 AUMs on South Slope in 1963. With these higher numbers of livestock AUMs, utilization of total available forage approached 60% during the grazing period from mid-September to late October. Although Demarchi (1965) attributed some forage declines to trampling and weathering, the total reduction corresponded relatively closely to forage requirements/AUM of cattle grazing.

Scheffler (1972) similarly showed relatively high reductions in forage availability for wintering bighorn sheep subsequent to summer grazing by cattle in the Ashnola. Comparison of grazed and ungrazed vegetation at two exclosures on Crater and Flatiron Mountains revealed 61 and 67 percent utilization of Sandberg's bluegrass/Junegrass and Kentucky bluegrass vegetation respectively. In contrast however, summer utilization equalled only 32% in a Sandberg's bluegrass/Columbia needlegrass community and only approximately 28% on a South Slope site supporting a bluebunch wheatgrass community.

Such data illustrate that utilization of forage by cattle may not be uniform, with presumed proper utilization of 50% exceeded in some areas but unattained at others. However, 50% utilization of forage by cattle may still be too severe relative to the needs of sheep, which depend upon sufficient winter forage remaining subsequent to summer and fall cattle grazing.

Because of the complexity of ecological relationships, animal unit months of cattle and bighorn sheep grazing do not necessarily comprise rigid tradeoffs. For instance, in 1910, bighorn sheep in the Ashnola equalled less than 100 individuals, increasing throughout the next 4 decades, during the most severe periods of domestic livestock use, to approximately 250 animals in 1955 (Demarchi 1965). Sheep numbers on South Slope then remained relatively constant until 1960, increasing thereafter to a peak in 1967, while lamb/ewe ratios ranged from .42 to .69 between 1960 and 1967 (Appendix H). Following removal of cattle in 1968 however, total sheep numbers declined, as did lamb/ewe ratios, which ranged from .27 to .13 between 1970 and 1977. Subsequent to reintroduction of cattle in 1978, lamb/ewe ratios improved to .47, although declining gradually to .24 by 1983 (Appendix H).

Such data are correlative, and should not be construed as indicating that the presence of cattle necessarily benefits bighorn sheep. For example, reintroduction of livestock in 1977 coincided with mild winters and winter feeding of bighorn sheep, both of which likely contributed to improved lamb/ewe ratios observed in 1978. Consequently, climatic factors may have compensated for any potentially negative interactions between bighorn sheep and cattle. Alternatively, cattle grazing may have benefited bighorn sheep by preventing excessive accumulation of standing litter, thereby improving sheep accessibility to spring growth and fall regrowth of bunchgrasses. Indeed, bighorn sheep have been observed to utilize Ashnola pastures recently vacated by cattle.

Cattle grazing may also enhance fall nutritive value of forage plants by delaying plant physiological cycles such that nutrients are fixed in the foliar portions of plants rather than being translocated to the roots prior to the onset of summer dormancy. Such cattle management techniques have reportedly benefitted elk in central Oregon (Anderson and Scherzinger 1975), and have been experimentally verified by Pitt (1985) as physiologically possible within bluebunch wheatgrass plants.

A computer model of bluebunch wheatgrass growth also supports potential improvements in crude protein and biomass yield following select grazing regimes (Allaye-Chan 1984). The model, developed at the physiological level and validated against empirical data collected by Harper (1969) in the Ashnola region, may be used to identify the quality and quantity of forage which is available at the time of livestock grazing, as well as the quality and quantity of regrowth which occurs following livestock grazing. Thus, the manner in which the forage resource is partitioned between bighorn sheep and cattle can be readily identified. Simulation results indicate that, under climatic conditions observed by Harper (1969) in 1967, forage availability in the fall is increased relative to ungrazed plants when livestock grazing occurs before July at 25% intensity. Regardless of defoliation date, livestock grazing at 50, 75, or 100% intensities generally did not increase forage availability in the fall. In contrast to biomass yield, crude protein yield is improved by livestock grazing at 50% intensity in the spring. Livestock grazing may occur at a higher intensity or at a later date for an improvement in crude protein yield than for an improvement in biomass yield, since improvements in crude protein yield are promoted by enhanced nitrogen concentrations as well as stimulated foliage production.

Nutritional enhancements may occur annually on Flatiron Mountain, as the Ashnola Slopes, Flatiron and Starvation Flats management units are all grazed by cattle prior to mid-June, when regrowth herbage is still most likely to occur (Harper 1969). Similarly, nutritional improvements may also occur in the North Crater Slope-East Crater Basin, South Crater Slope and Meausette Creek management units on Crater Mountain following cattle grazing in alternate years.

The potential value of cattle grazing to improve fall and winter forage quality for California bighorn sheep assumes subsequent utilization by bighorn sheep. For example, the Ashnola Slopes, Flatiron and Starvation Flats management units receive only light utilization by bighorn sheep. Alternatively, Juniper Slope, which supports frequent sheep utilization during fall and winter, is grazed too late by cattle to promote significant stimulation of regrowth. However, percent crude protein of the regrowth may be significantly higher than ungrazed vegetation (Alaye-Chan 1984, Pitt unpub. data).

A third potential benefit attributed to cattle grazing is the promotion of a seral community rich in forbs, which often constitute preferred forages of California bighorn sheep. Such successional changes require relatively heavy cattle grazing in order to reduce the competitive advantage of dominant grass species. Current proper grazing use standards however, are established to maintain vigor and reproductive health of these climax, perennial bunchgrasses, thereby preventing successional changes toward a more seral plant community.

Potential, theoretical benefits of cattle grazing may be difficult to achieve in practice. Moreover, even if cattle grazing improves forage quality, no evidence exists that increased recruitment rates of bighorn sheep will result. Certainly however, the previous discussion indicates that cattle need not be viewed as inherently deleterious to California bighorn sheep. Judicious control of cattle stocking rates, grazing seasons and distribution will minimize detrimental impacts, and may even produce some benefits.

Current livestock management is much superior to that practiced prior to 1968. Historically, cattle grazed on Ashnola grasslands continuously from approximately April 10 to the arrival of snow in November. Range readiness criteria now determine spring turnout, which usually does not occur until approximately May 15, while stocking rates are established to leave appropriate stubble heights of 10-15 cm (4-6 inches) on key forage species. Livestock control has also been improved with 14.5 km (9 miles) of crossfencing constructed since 1976. Moreover, domestic sheep, which posed a more serious ecological overlap with bighorn sheep, no longer utilize Ashnola ranges. Consequently, current cattle management activities exert much reduced impacts on California bighorn sheep relative to livestock grazing prior to 1968, particulary since livestock use is concentrated on Crater Mountain while bighorn sheep use is concentrated on Flatiron Mountain. Indeed, field observations by some of the personnel interviewed suggest that forage occasionally remains underutilized, perhaps indicating potential for increased allocation of cattle AUMs.

Stocking rates for cattle are currently based upon proper utilization guidelines, without knowledge of available forage production. Nonetheless, some increased cattle use could likely occur without detrimental impacts on the bighorn sheep herd. However, recommendations for optimal cattle numbers are difficult to determine quantitatively without more accurate information regarding seasonal availability of forage in each pasture during the time(s) of peak use, whether that grazing use results from cattle, mule deer or bighorn sheep.

Similar to those data provided by Morrison (1972), the current precise impacts of cattle grazing on California bighorn sheep can be assessed best with accurate sampling of pasture-specific forage production and weathering losses, plus seasonal forage utilization and requirements of both cattle and bighorn sheep. Previous information provided by Demarchi (1965), Morrison (1972), Scheffler (1972) and Demarchi (1973a) serve as useful guidelines, but do not provide information specific to current cattle management programs and pasture units.

RESPONSE OF CALIFORNIA BIGHORN SHEEP TO MANAGEMENT ACTIVITIES

The previous discussion illustrates that no measurable response in California bighorn sheep in the Ashnola can be attributed solely to recent alterations in cattle numbers or management activities. No increase in sheep numbers resulted following the removal of cattle in 1968, while no substantial decline in sheep numbers occurred following reintroduction of cattle in 1977. Similarly, the continual decline in lamb production following cattle removal in 1968 led Spalding (1973) to conclude that forage competition with cattle did not represent the most serious limitation to bighorn sheep between 1960 and 1967.

Lamb/ewe ratios increased from 0.16 in 1977 to 0.47 in 1978 following winter feeding of sheep in 1977. Although Ramsay (1980) credited this improvement primarily to increased consumption of protein during the final stages of gestation, results were confounded with a relatively mild winter plus mineral supplements provided simultaneously with winter feed. Such supplements, which included salt, calcium, phosphorus, vitamins A, D2 and E, copper, manganese, zinc, iron, cobalt, iodine and selenium, may have contributed to increased lamb/ewe ratios as much as increased availability of protein or forage.

Lamb/ewe ratios declined during the next two years of winter feeding in 1979 (.34) and 1980 (.32), casting some doubt on the guaranteed efficacy of winter feeding. Moreover, anithelminthic drugs were also provided, beginning in 1978, further confounding conclusions regarding the benefits of winter feeding and/or mineral supplements. Although Ramsay (1980) reported lower lungworm infestations in 1978 and 1979 compared to values documented by Blood (1961) in 1960-1961, no data regarding infestations in 1977 were provided. Consequently, the benefits of antihelminthic drugs on South Slope can not be quantified.

Prescribed burning occurred on South Slope during the springs of 1976, 1978 and 1979 (Ramsay 1980). All three fires burned areas of relatively flat terrain, which normally received comparatively light spring use by bighorn sheep (Ramsay 1980). Field observations by Ramsay (1980) confirmed continued light use of these burned areas, while sheep pellet group counts remained higher on slopes with steeper terrain. Ramsay (1980) therefore concluded that controlled burns appeared not to produce greater sheep use of flatter terrain areas.

In the spring of 1980, a controlled fire burned upper portions of South Slope where Ramsay (1980) had previously observed intensive sheep use. Spring counts in 1980 however, indicated that no sheep utilized these burned sites, prompting Ramsay (1980) to conclude that recently burned grasslands contributed relatively minor amounts to nutritional intake of California bighorn sheep on winter/spring ranges.

Burning of optimal bighorn sheep habitat certainly does not create additional optimal bighorn sheep habitat. Indeed, total forage in these habitats is obviously initially reduced by prescribed fires. Consequently, future controlled burning is scheduled for forested areas adjacent to South Slope, with increased availability of grasslands as a primary objective.

However, burning to improve habitat for sheep may reduce desired habitat for mule deer, which preferentially seek forested areas and browse throughout most of the calendar year. Such managerial trade-offs should be considered prior to all habitat enhancement programs, which ideally should quantify ecological costs and benefits of proposed management activities.

No organized predator control program existed in the Ashnola prior to 1951, which may have contributed to peak coyote populations in 1950 (Blood 1961). Poison baits were distributed in 1951 and 1957, thereby reducing coyote numbers to approximately 10-20 individuals by 1960 (Blood 1961). Cougars and bobcats were also reduced to relatively low numbers by 1960, with approximately 70 cougars and 40 bobcats killed between 1940 and 1960 (Blood 1961).

In spite of this predator control, bighorn sheep numbers failed to increase appreciably between 1950 and 1960, causing Blood (1961) to conclude that predation did not seriously limit bighorn sheep populations in the Ashnola. Conceivably however, sufficient numbers of predators remained to reduce lamb survival immediately following birth, as Harper (1984) estimated that predation by only 15 coyotes could account for all lamb losses observed during 1982 and 1983. Indeed, Blood (1961) noted that no visible evidence of coyote predation did not offer conclusive proof that significant predation did not occur. Similarly, lamb production may not have increased following the 1973 predator control program because of incomplete eradication of predators. Although many predators were removed between January and April of this year, direct observations or fresh signs of coyotes, bears, cougars and bobcats persisted through late April, May and

June (Ministry of Environment field notes).

No predator control program currently exists in the Ashnola, while total sheep numbers are larger than those of 1950, when coyote control existed. Lamb/ewe ratios however, appear significantly lower than during the 1950's, in spite of winter feeding, antihelminthic drugs, mineral supplements, improved livestock control and reservation of South Slope for exclusive sheep use. Such circumstantial evidence suggests that predation may be depressing population growth of bighorn sheep, although no uncounfounded, direct data exist to either confirm or refute such an hypothesis. Significantly however, population growth and lamb/ewe ratios have not been obviously and/or permanently enhanced with alternative management activities.

MANAGEMENT ALTERNATIVES FOR THE ASHNOLA REGION

California bighorn sheep have been designated as the primary resource user of the Ashnola. This fact necessarily indicates secondary priority for all other resource products. Consequently, even though livestock AUMs could likely be increased from current levels without significant detrimental impacts on bighorn sheep, any change in present cattle management activities or numbers should proceed with caution.

Alternatively, even though California bighorn sheep represent an administratively established resource priority, they are still subject to population limits imposed by ecological constraints. For example, historical numbers of bighorn sheep in the Ashnola are almost certainly unattainable on a practical basis, as traditional migration routes and low elevation wintering areas in valley bottoms have both been altered or eliminated with settlement and development throughout the Similkameen Valley.

The proper mix of cattle and bighorn sheep in the Ashnola incorporates political as well as biological components. Removal of cattle in 1968 represented a policy decision, albeit based upon biological arguments. Return of cattle in 1977 followed a similar path. Undoubtedly, future decisions regarding the appropriate mix of cattle and bighorn sheep in the Ashnola will also be expressed ultimately with policy statements.

No Provincial or regional guidelines exist by which to assess "proper" mixes of wildlife and livestock relative to society's goals. Therefore, actual mixes of livestock and wildlife often express the professional and personal backgrounds of local resource managers. Such resource management participants in the Ashnola are well trained, experienced and generally express a cooperative attitude. It would therefore be presumptuous for this Problem Analysis to suggest a "proper" mix of cattle and bighorn sheep. Such a unilateral recommendation usurps both the legitimate responsibility of local resource managers, and also inappropriately substitutes personal preference, no matter how objective, for social and political decisions made more properly by society as a whole.

Undoubtedly however, from a purely biological perspective, livestock grazing and California bighorn sheep can coexist relatively harmoniously in the Ashnola. Assuming proper stocking rates of each animal species, the primary biological questions concern specific forage management techniques and utilization rates relative to the needs of cattle and bighorn sheep. At present, many biological constraints, including those from both a plant and an animal perspective, remain poorly defined. Estimation of carrying capacity must entail consideration of bighorn sheep requirements for food, water, and shelter on a site-specific, management unit basis. As previously discussed however, the capacity of such management units as South Slope lambing grounds has not yet been quantified, and uncertainty exists for many factors governing forage availability.

Another issue resulting from inadequate knowledge concerns the efficiency of the current rest-rotation system. The ranching community believes that current grazing patterns on Crater Mountain needlessly waste grazing opportunities in those pastures rested during alternate years. Moreover, weight gains are reduced to virtually nil when cattle are forced to consume year old grass during the spring grazing period subsequent to a year of rest. Consequently, the ranching community prefers that the present rest-rotation schedules be altered in favor of livestock grazing patterns that utilize all pastures during some portion of the year. Such annual use would not only promote improved cattle weight gains, but may also enhance forage conditions for bighorn sheep through improved quality and availability.

Potential benefits of cattle grazing relative to bighorn sheep are theoretically possible, but remain unverified in practice. Nonetheless, the opportunity for such refined forage management is facilitated with fencing erected since 1976, which provides good control of cattle movements relative to specific forage management goals. Certainly, optimal forage management requires flexible livestock management policies. Actual movements of cattle may therefore occasionally deviate from formalized schedules, depending upon opportunities and/or constraints which arise during any specific grazing year. Current grazing management programs should be evaluated on a regular basis to ensure that specific objectives for cattle, bighorn sheep and forage are being attained.

Regardless of foraging opportunities however, South Slope should continue to be reserved for exclusive use by California bighorn sheep. South Slope represents the only large grassland in the Ashnola with adjacent lambing cliffs, plus steep slopes which generally remain free of snow accumulation during winter. Such winter ranges are extremely important for bighorn sheep, particularly in view of Morrison's (1972) observation that during the severe winter of 1968-1969, even South Slope became snow-covered, with subsequent sheep migration to lower elevations.

Although cattle utilized South Slope for fall grazing prior to 1968, the risk of reintroducing cattle to this sheep wintering area seems unwarranted relative to the formal designation of bighorn sheep as the primary resource user. For example, anecdotal information suggests that bighorn sheep populations increased by approximately 50% following removal of cattle from winter ranges on the Junction Unit. Even if cattle grazing could occur on South Slope without detrimental impacts on bighorn sheep, these winter ranges should still be reserved for exclusive use by sheep, purely from an aesthetic point of view. Few areas remain where large numbers of California bighorn sheep can be observed within comparatively pristine conditions.

Protection of these pristine conditions requires that other kinds of resource use also be controlled. Unrestricted recreational use threatens both livestock and wildlife. Vandalism, opened gates and shooting of livestock during hunting season impairs cattle managment programs, and reduces the spirit of cooperation. Uncontrolled off-road vehicle use invites habitat destruction, poaching, occasional callous chasing of livestock and wildlife, and may initiate invasion of noxious weeds such as knapweed. Resource managers should therefore determine the kind and amount of recreational use consistent with primary resource objectives in the Ashnola.

These resource objectives should also identify specific population numbers and recruitment rates desired for the California bighorn sheep population. Management alternatives for hunting, winter feeding, predator control and prescribed burning can then be formulated and priorized relative to specific goals. For example, prescribed burning may be most effective for enhancing carrying capacity, while predator control may be more efficient for increasing recruitment rates. However, if predation of lambs by coyotes does indeed severely depress recruitment rates, then prescribed burning in the absence of predator control would be an inappropriate management priority.

Future plans for prescribed burning should be evaluated and implemented with caution. Peek et al. (1984) summarized seven case histories of prescribed burning for enhancement of bighorn sheep habitat, and reported extremely variable results. Consequently, Peek et al. (1984) concluded that prescribed burning does not necessarily increase bighorn sheep populations, and may occasionally produce negative effects, such as reduced total nutrient availability. Prescribed burning should therefore not be considered a management panacea, but must be planned carefully relative to specific, quantifiable objectives for forage and bighorn sheep. Some objectives of prescribed burning, such as increased forage availability through removal of old growth, may even be achieved more predictably with livestock grazing, which eliminates the risk of fire escape associated with prescribed burning.

Regardless of which management alternatives are selected however, each should be monitored rigorously so that the degree of success or failure can be determined. Consequently, it is imperative to adopt a mutually acceptable system of monitoring response of habitat, cattle and bighorn sheep. Such monitoring necessarily should occur following any changes in management activities, including livestock numbers and grazing rotations. Optimal resource management evolves best from quantified measurement of resource response to managerial inputs.

Proposed management alternatives should also acknowledge that resource limits do indeed exist. Conceivably, cattle and California bighorn sheep numbers already approach such limits, and may therefore not be amenable to substantial future increases. More of any resource is not possible indefinitely. Optimal resource management seeks stabilization of resource production and extraction without exceeding biological limits. Projected numbers of cattle, mule deer and California bighorn sheep should therefore be related not only to personal and professional objectives, but also to quantified estimates of carrying capacity for all grazing ungulates in the Ashnola region.

INFORMATION REQUIREMENTS FOR THE ASHNOLA REGION

The following list summarizes the kind of information that would most likely promote more knowledgeable resource management in the Ashnola region.

1. Current numbers of California bighorn sheep and mule deer should be determined at prescribed levels of accuracy and precision. Such data should be collected at specific times of the calendar year to provide reliable, comparable estimates of trends in population numbers.
2. Current habitat use and distribution of California bighorn sheep should be determined both spatially and temporally. Such information is needed to assess the potential ecological impact of current cattle management activities on California bighorn sheep.
3. Forage biomass and nutrient production should be determined, on a management unit and/or habitat basis, during the season(s) of peak use by cattle and California bighorn sheep.
4. The impacts of current cattle grazing rotations on forage production, availability and quality should be determined on a management unit basis. Proper use guidelines, such as stubble heights, should also be quantified, and may vary with season of cattle use. Such information is required to assess the impact of cattle grazing on plant vigor, and to determine the level of cattle use potentially detrimental to California bighorn sheep.
5. Cattle weight gains during each period of grazing rotation use should

be monitored to assess the impact of rotational grazing strategies on livestock production.

6. Exclosures should be established in each management unit to assess the long term impacts of grazing on botanical composition and forage production. Ideally, these exclosures will alternatively exclude cattle and California bighorn sheep to assess the relative influences of these two grazing ungulates. Previous exclosure placements do not invariably reflect current management activities, and are often either too small or in disrepair. Where possible however, previous transects, plots and exclosures should be relocated, repaired and resampled on a regular basis to provide continuity and direct comparability of data.
7. Classification counts of California bighorn sheep should be determined regularly, at specific times of the year. Such data must be collected at prescribed levels of accuracy and precision, and are required to predict impending changes and/or to assess trends in recruitment rates and population growth.
8. Parameters which are mutually acceptable to the Ministries of Agriculture and Food, Environment and Forests, as indicative of population quality, should be monitored in the bighorn sheep. This information is needed to identify direct impacts of livestock management on bighorn sheep.
9. The circumstantial evidence of substantial predation of lambs by coyotes must be confirmed or refuted. Such information is required prior to allocating significant funds toward other habitat enhancement programs.

10. Future prescribed burning should be monitored to assess subsequent impacts on forage availability, forage production and quality, bighorn sheep distribution and soil nutrients. Such information is required to determine optimal fire intensity, timing and periodicity for habitat enhancement.

RESEARCH PRIORITIES AND STRATEGIES

The previous list of information requirements summarized only those research programs believed to be most urgent and pertinent to management of the Ashnola grasslands for cattle and California bighorn sheep. Specfic recommendations address information gaps, as well as differing opinions among resource management personnel regarding site-specific application of management techniques. Hopefully, such site-specific information will alleviate these disagreements, and further the mutually cooperative attitudes expressed during interviews. As such, all 10 recommended research items merit high consideration. The highest priority however, should be to determine quantitatively whether coyote predation contributes significantly to current low lamb/ewe ratios.

To achieve these research objectives, all information gathering activities must be well planned and supervised. Specific research hypotheses and strategies should all be reviewed, approved and administered by a single research coordinator. Conclusive, unconfounded results depend upon such rigorous, experimental control, particularly in extensive, long term field research, which inherently is plagued with uncontrollable, environmental factors.

SUMMARY

Detailed summaries regarding specific topics are contained throughout the text. The following list summarizes those conclusions and recommendations most pertinent to the Problem Analysis Terms of Reference.

1. Resource participants in the Ashnola region generally acknowledge California bighorn sheep as the primary resource user. Disagreements focus primarily on appropriate cattle management activities and stocking rates relative to continued reproductive health of forage and sheep populations.
2. Forage production apparently increased on Flatiron Mountain between 1960 and 1963. Such increased forage production accelerated between 1963 and 1972, presumably in response to removal of cattle in 1968.
3. Total foliar cover on Crater and Flatiron Mountains between 1960 and 1967 declined significantly both inside and outside grazing exclosures, indicating response not only to grazing pressure, but also to the influence of variable annual weather patterns.
4. Foliar cover of bluebunch wheatgrass, junegrass and Idaho fescue on Crater Mountain between 1960 and 1967 declined both inside and outside grazing exclosures, indicating response not only to grazing pressure, but also to the influence of variable annual weather patterns.
5. Foliar cover of bluebunch wheatgrass improved under protection from grazing at one South Slope exclosure between 1960 and 1967, but remained relatively unaffected by grazing at a second exclosure.

6. Botanical changes on Flatiron Mountain between 1967 and 1972 provide inconsistent conclusions, as climax and seral plant species both displayed increases, decreases, and/or relative stability in foliar cover among different sampling sites.
7. Satisfactory foliar cover, including that of climax plant species, apparently exists throughout most of Crater and Flatiron Mountains at present.
8. Fears regarding extensive loss of grassland on Flatiron Mountain due to forest encroachment appear unfounded.
9. No evidence exists to suggest that California bighorn sheep in the Ashnola suffer any losses due to toxic plants.
10. Peak rutting activity occurs between mid- and late November, confined primarily to winter ranges and their immediate vicinity.
11. Lambing season extends from late April to mid-June, peaking in May. Known lambing grounds are confined primarily to precipitous cliffs and rock outcroppings immediately adjacent to South Slope grassland communities utilized as winter/spring range.
12. The diet of California bighorn sheep consists primarily of grasses throughout the year, although forbs and pasture sage display high forage preference indices during spring and early winter respectively.
13. Optimal California bighorn sheep habitat includes a) escape terrain for lamb/ewe groups adjacent to spring ranges, and b) a variety of forages including grasses, forbs and woody plants, all of which contribute to diet and forage preferences during different and specific portions of the grazing year.

14. Optimal California bighorn sheep habitat in the Ashnola is characterized best by a vegetational mosaic of climax and seral plant communities available primarily within steppe bunchgrass vegetation.

15. California bighorn sheep numbers in the Ashnola declined rapidly between 1880 and 1909, and remained low in 1950. Populations generally increased between 1950 and 1967, but declined slightly following 1967.

16. Lamb/ewe ratios on South Slope ranged from .42 to .69 between 1960 and 1967, but averaged only .25 between 1970 and 1983.

17. Inclement weather, parasites, diseases and hunting likely do not limit recruitment rates of bighorn sheep in the Ashnola.

18. Conception rates of bighorn sheep in the Ashnola apparently approach 100%, and therefore do not limit recruitment rates.

19. Lamb/ewe ratios increased to .47 in 1978 following winter feeding. Such feeding programs coincided with relatively mild winters, mineral supplements and provision of anithelminthic drugs. Subsequent to 1978, lamb/ewe ratios declined gradually to .24 by 1983.

20. Strong circumstantial evidence suggests that predation of lambs by coyotes currently depresses recruitment rates of California bighorn sheep in the Ashnola.

21. California bighorn sheep and cattle generally depend upon and utilize similar forage species. Differing preferences for terrain and specific plant species reduces but does not eliminate potential competition between cattle and bighorn sheep.

22. California bighorn sheep populations did not increase following removal of cattle in 1968. Current cattle management activities are superior

to those prior to 1968, and do not pose significant threats to the continued welfare of bighorn sheep in the Ashnola.

23. Transmission of disease between cattle and California bighorn sheep in the Ashnola appears negligible.

24. Habitat and forage preferences of mule deer differ markedly from California bighorn sheep, and likely exert relatively negligible influences on grassland production and forage availability to sheep.

25. Potential benefits of cattle grazing relative to increased availability and quality of forage for California bighorn sheep are theoretically possible, but remain unverified.

26. Optimal numbers of cattle and California bighorn sheep can be determined best with new information regarding forage availability within management units and/or habitats during specific periods of use by each ungulate species.

27. South Slope should continue to be reserved for exclusive use by California bighorn sheep.

28. Future research should a) document the degree of coyote predation of lambs, b) quantify current seasonal distribution and numbers of California bighorn sheep in the Ashnola, and c) assess the impacts of current cattle management rotations on forage production, forage quality, forage availability, plant vigor and livestock weight gains.

29. All changes in management activities should be monitored carefully so that the degree of success or failure can be determined quantitatively. Such monitoring is required to further refine and improve managerial skills and goals.

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APPENDIX A

Ashnola Research Committee

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APPENDIX B

Personnel Interviewed

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APPENDIX C

Grazing Rotations on Crater and Flatiron Mountains

Grazing Rotation for Even-numbered years on Crater Mountain

Stocking	Date	Range Unit	AUMs
120 cows	May 15-July 15	North Crater Slope-East Crater Basin	240
180 yearlings	May 15-July 15	North Crater Slope-East Crater Basin	360
120 cows	July 16-Aug. 31	Crater Alpine	180
180 yearlings	July 16-Aug. 31	Crater Alpine	270
120 cows	September 1-15	West Crater Basin	60
180 yearlings	September 1-15	West Crater Basin	90
120 cows	Sept. 16-Oct. 31	Hargreaves Pasture	180
180 yearlings	Sept. 16-Oct. 31	Hargreaves Pasture	45
		Total AUMs	1425

Grazing rotation for odd-numbered years on Crater Mountain

Stocking	Date	Range Unit	AUMs
120 cows	May 15-June 15	South Crater Slope	120
120 cows	June 15-July 15	Meausette Creek	120
180 yearlings	May 15-July 15	South Crater Creek	180
180 yearlings	June 15-July 15	Meausette Creek	180
120 cows	July 16-Aug. 31	Crater Alpine	180
180 yearlings	July 16-Aug. 31	Crater Alpine	270
120 cows	September 1-15	West Crater Basin	60
180 yearlings	September 1-15	West Crater Basin	90
120 cows	Sept. 16-Oct. 31	Hargreaves Pasture	180
180 yearlings	Sept. 16-Oct. 31	Hargreaves Pasture	45
		Total AUMs	1425

Grazing Rotation for Flatiron Mountain

Stocking	Date	Range Unit	AUMs
100 cows	May 7-31	Ashnola Slopes	75
100 cows	June 1-21	Flatiron and Starvation Flats	75
100 cows	June 22-July 15	Juniper Slope	75
100 cows	July 16-31	Observation Flat	50
100 cows	Aug. 1-Sept. 15	Joe Lake Alpine	200
		Total AUMs	475

APPENDIX D

Forage Production (lbs/acre;kg/ha) of Ashnola Plant Communities

Plant Community	Production *	Sampling Date	Citation
Bluebunch Wheatgrass	1226;1373	July 1967	Harper (1969)
	1030;1154	July 1968	Harper (1969)
	864; 968	October 1968	Morrison (1972)
Bluebunch Wheatgrass-Idaho Fescue	868; 972a	October 1960	Blood (1961)
	697; 781b	October 1960	Blood (1961)
	871; 976	October 1960	Blood (1961)
	1040;1165	August 1963	Demarchi (1965)
	1045;1170b	August 1963	Demarchi (1965)
	777; 870a	August 1963	Demarchi (1965)
	929;1040	August 1963	Demarchi (1965)
	651; 729c	August 1963	Demarchi (1965)
	1730;1938b	July 1971	Demarchi (1973a)
	854; 956c	July 1971	Demarchi (1973a)
	2061;2308b	July 1972	Demarchi (1973a)
	1430;1602a	July 1972	Demarchi (1973a)
	632; 708c	July 1972	Demarchi (1973a)
Bluebunch Wheatgrass-Junegrass	637; 713d	October 1960	Blood (1961)
	980;1098	August 1963	Demarchi (1965)
	780; 874d	August 1963	Demarchi (1965)
	832; 932	August 1963	Demarchi (1965)
	740; 829	August 1963	Demarchi (1965)

	1508;1688d	July 1971	Demarchi (1973a)
	1260;1411d	July 1972	Demarchi (1973a)
Bluebunch Wheatgrass-Columbia Needlegrass	521; 583	September 1968	Morrison (1972)
Bluebunch Wheatgrass-Pasture sage	606; 679	Summer 1967	Scheffler (1972
Mountain Big Sagebrush-Idaho Fescue	861; 964	August 1963	Demarchi (1965)
	720; 806	August 1963	Demarchi (1965)
	814; 912	August 1963	Demarchi (1965)
Pasture Sage-Junegrass	114; 128e	October 1960	Blood (1961)
	241; 270f	October 1960	Blood (1961)
	326; 365f	August 1963	Demarchi (1965)
	494; 553e	August 1963	Demarchi (1965)
	1051;1177e	July 1971	Demarchi (1973a)
	579; 648f	July 1972	Demarchi (1973a)
	636; 712e	July 1972	Demarchi (1973a)
Sedge	1232;1380	September 1968	Morrison (1972)
Timber Oatgrass-Sedge	1579;1768	September 1968	Morrison (1972)
Junegrass-Sandberg's Bluegrass	319; 357g	July 1964	Demarchi (1965)
	1247;1397	Summer 1967	Scheffler (1972)
	844; 945g	July 1972	Demarchi (1973a)
Kentucky Bluegrass	302; 338h	October 1960	Blood (1961)
	1627;1822	July 1967	Harper (1969)
	1380;1546	July 1968	Harper (1969)
	396; 443	September 1968	Morrison (1972)

	2375;2660h	July 1972	Demarchi (1973a)
Kentucky Bluegrass-Columbia Needlegrass	1784;1998i	July 1964	Demarchi (1965)
	1750;1960	Summer 1967	Scheffler (1972)
	1188;1330i	July 1971	Demarchi (1973a)
	1518;1700i	July 1972	Demarchi (1973a)
Columbia Needlegrass-Cheatgrass	824; 923j	October 1960	Blood (1961)
	701; 785j	July 1964	Demarchi (1965)
	1415;1585	September 1968	Morrison (1972)
	1599;1791j	July 1972	Demarchi (1973a)
Columbia Needlegrass-Sandberg's Bluegrass	1230;1377	July 1964	Demarchi (1965)
Pinegrass	703; 787	July 1967	Harper (1969)
	407; 456	July 1968	Harper (1969)

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* Production values within the same plant community followed by identical letters are collected from the same or equivalent plots.

APPENDIX E

Comparison of Foliar Cover Between 1960 and 1967 for 2 Grazed Sites on South Slope, Flatiron Mountain.

	SITE D		SITE J	
	1960	1967	1960	1967
Bluebunch Wheatgrass	11	14	6	2
Cheatgrass		1		Tr
Columbia Needlegrass	Tr	3	14	14
Idaho Fescue	Tr		Tr	
Junegrass	10	6	8	10
Kentucky Bluegrass	4	Tr	11	2
Sedge			2	
TOTAL GRASSES AND SEDGES	26	24	41	28
Cinquefoil			Tr	
Fleabane			Tr	
Lupine			2	Tr
Penstemon	Tr			
Phacelia	Tr			
Pussytoes	2		2	Tr
Rockcress			2	Tr
Yarrow	4		2	Tr
Yellow Locoweed/ Timber Milkvetch			Tr	
TOTAL FORBS	6	5	8	Tr

APPENDIX E - CONTINUED

	SITE D		SITE J	
	1960	1967	1960	1967
Pasture Sage	5		2	Tr
Wild Buckwheat	3		2	Tr
TOTAL CHAMAEPHYTES	8	2	4	Tr
TOTAL LIVING PLANTS	40	30	57	28
LITTER	12	25	18	46
BAREGROUND	48	41	25	26

APPENDIX F

Comparison of Foliar Cover Between 1960 and 1967 for 2 Grazed Sites on Crater Mountain.

	SITE 1		SITE 2	
	1960	1967	1960	1967
Bluebunch Wheatgrass	20	5	22	9
Cheatgrass	Tr	Tr		
Columbia Needlegrass				Tr
Idaho Fescue			13	
Junegrass	9	4	10	6
Kentucky Bluegrass	9		6	
TOTAL GRASSES + SEDGES	38	9	51	15
Balsamroot	1	2	7	
Fleabane	3		Tr	
Lupine	4	Tr	1	
Nodding Onion		Tr		
Phacelia	1		Tr	
Pussytoes	Tr			
Yarrow	1	Tr	1	
TOTAL FORBS	12	4	10	5

APPENDIX F - CONTINUED

	SITE 1		SITE 2	
	1960	1967	1960	1967
Pasture Sage	2	Tr	2	Tr
Wild Buckwheat	Tr	Tr	1	Tr
TOTAL CHAMAEPHYTES	2	Tr	3	Tr
TOTAL LIVING PLANTS	52	16	66	20
LITTER	4	12	8	26
BAREGROUND	44	72	26	48

APPENDIX G

Foliar Cover of Some Important Plant Species in 6 Grassland Communities on Flatiron Mountain in 1960, 1963, 1971 and 1972.

VEGETATION COMMUNITY	SITE	PLANT SPECIES	FOLIAR COVER (%)			
			1960	1963	1971	1972
Bluebunch Wheatgrass - Idaho Fescue	a	Bluebunch Wheatgrass	24	30		26
		Idaho Fescue	4	43		4
		Junegrass	9	4		8
		Pasture Sage	4	3		10
	b	Bluebunch Wheatgrass	14	64	43	39
		Idaho Fescue	0	15	3	3
		Junegrass	5	3	1	5
		Pasture Sage	45	10	Tr	2
	c	Bluebunch Wheatgrass		51	16	7
		Idaho Fescue		16	Tr	7
		Junegrass		7	2	5
		Sandberg's Bluegrass		6	1	9
		Pasture Sage		12	12	7
Bluebunch Wheatgrass - Junegrass	d	Bluebunch Wheatgrass	11	47	35	49
		Junegrass	10	8	2	6
		Pasture Sage	4	14	6	10

VEGETATION COMMUNITY	SITE	PLANT SPECIES	FOLIAR COVER (%) 1960	1963	1971	1972
Pasture Sage - Junegrass	e	Bluebunch Wheatgrass			3	2
		Columbia Needlegrass		10	25	3
		Idaho Fescue				Tr
		Junegrass		10	Tr	9
		Sandberg's Bluegrass		8	18	18
		Pasture Sage		53	17	26
	f	Bluebunch Wheatgrass	2	2		4
		Junegrass	12	12		4
		Sandberg's Bluegrass	7	17		9
		Pasture Sage	9	22		11
Junegrass - Sandberg's Bluegrass	g	Bluebunch Wheatgrass		1		6
		Junegrass		28		10
		Sandberg's Bluegrass		32		22
		Pasture Sage		6		10
		Rabbitbrush		Tr		8
Kentucky Bluegrass - Columbia Needlegrass	h	Cheatgrass		Tr		7
		Columbia Needlegrass		1		44
		Kentucky Bluegrass		82		42
		Dandelion		Tr		4
		Pasture Sage		Tr		3
		Yarrow		2		13

VEGETATION COMMUNITY	SITE	PLANT SPECIES	FOLIAR COVER (%) 1960	1963	1971	1972
	i	Bluebunch Wheatgrass		Tr		1
		Cheatgrass				
		Columbia Needlegrass		8	26	14
		Kentucky Bluegrass		76	22	24
		Dandelion		Tr	Tr	3
		Pasture Sage		Tr	18	26
		Wild Buckwheat		Tr	6	2
		Yarrow		1	5	12
Columbia Needlegrass - Cheatgrass	j	Bluebunch Wheatgrass	6	5		20
		Cheatgrass	0	12		0
		Columbia Needlegrass	14	65		19
		Idaho Fescue		Tr		14

APPENDIX H

Classification Counts on South Slope between 1960 and 1983

Year	Ewes (E)*	Lambs (L)	Yearlings (Y)	L/E Ratio	Y/E Ratio
1960	58	35	11	.60	.19
1961	23	16	14	.69	.61
1963	53	23	16	.43	.30
1964	72	30	17	.42	.24
1967	107	49	34	.46	.31
1970	80	20		.25	
1971	93	23	14	.25	.15
1972	72	14	16	.19	.22
1973	67	12	7	.18	.10
1974	75	20	9	.27	.12
1975	80	10	10	.13	.13
1976	84	16	8	.19	.10
1977	62	10	15	.16	.24
1978	58	27	17	.47	.29
1979	56	19	29	.34	.52
1980	53	17	18	.32	.34
1982	81	23	17	.28	.21
1983	82	20	19	.24	.23

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* Ewes were classified as females 2 years and older

APPENDIX I

Parasites and Disease in California Bighorn Sheep of British Columbia

Coccidium (Eimeria spp.)

Broad tapeworm (Moniezia benedeni)

Fringed tapeworm (Thysanosoma actinoides)

Thin-necked bladderworm (Cysticercus tenuicollis)

Lungworm (Protostrongylus stilesi)

Sheep pinworm (Skrjabinema ovis?)

Abomassal worms (Ostertagia ostertagi)
(O. occidentalis)
(O. circumcincta)

Medium stomach worm (Marshallagia marshalli)

Thread-necked strongyle (Nematodirus spp.)

Ruminant whipworm (Trichuris discolor?)

Winter tick (Dermacentor albipictus)

Paralysis tick (Dermacentor venustus syn. andersoni)

Spinose ear tick (Otobius megnini)

Biting lice (Mallophaga spp.)

Bacteria (Flavobacter spp.)
(Corynebacterium spp.)
(alpha-Streptococcus)
(Staphyloccus aureus)

Virus (Parainfluenza type 3)

APPENDIX J

Glossary

ANIMAL UNIT: One mature cow (454 kg; 1000 lb.) with or without unweaned calf at side, or equivalent.

ANIMAL UNIT MONTH: The amount of feed or forage required by an animal unit for one month.

BOTANICAL COMPOSITION: The relative proportion of plant species in a stand or community.

CLIMAX: The state of a biotic community that is attained when population structures of all its species fluctuate rather than exhibit unidirectional change. Such a community will remain in a self-perpetuating state so long as present climatic, edaphic and biotic conditions continue.

FOLIAR COVER: The vertical projection of aerial plant parts to the ground.

PALATABILITY: Those plant characteristics which promote selection by grazing animals.

PRESCRIBED BURNING: The use of fire as a management tool under specified conditions to attain stipulated objectives.

RANGE CONDITION: The present state of vegetation of a range site in relation to the potential natural plant community for the site.

REST-ROTATION GRAZING: A specialized grazing system which identifies systematically recurring periods of rest and grazing of two or more pastures or management units.

SERAL: A non-climax plant species or community susceptible to replacement by another plant species or community.

STANDING CROP: The total amount of living, above ground plant material, per unit area, at a specific point in time.

STOCKING RATE: The number of specified kinds and classes of animals grazing or utilizing a unit of land for a specific period of time.

SUCCESSION: Unidirectional change that results in the partial or complete replacement of one plant community by another.

UTILIZATION: The proportion of the current year's growth or production that is removed by grazing animals.

APPENDIX K

Species List*

Grass and Grasslike Plants

Alpine bluegrass (*Poa alpina*)

Alpine timothy (*Phleum alpinum*)

Bluebunch wheatgrass (*Agropyron spicatum*)

Cheatgrass (*Bromus tectorum*)

Columbia needlegrass (*Stipa nelsonii*)

Crested wheatgrass (*Agropyron desertorum*)

Idaho fescue (*Festuca idahoensis*)

Junegrass (*Koeleria macrantha*)

Kentucky bluegrass (*Poa pratensis*)

Needleandthread (*Stipa comata*)

Pinegrass (*Calamagrostis rubescens*)

Rough fescue (*Festuca scabrella*)

Sandberg's bluegrass (*Poa sandbergii*)

Sedge (*Carex* spp.)

Sheep fescue (*Festuca ovina*)

Timber oatgrass (*Danthonia intermedia*)

Western wheatgrass (*Agropyron smithii*)

Forbs

Balsamroot (*Balsamorhiza sagittata*)

Bassia (*Bassia hyssopifolia*)

Brown-eyed Susan (*Gaillardia aristata*)

Cinquefoil (*Potentilla* spp.)

Dandelion (*Taraxacum officinale*)

Death camas (*Zygadenus venenosus*)

Knapweed (*Centaurea diffusa*)

Lemonweed (*Lithospermum ruderale*)

Long-leaved phlox (*Phlox longifolia*)

Nodding onion (*Allium cernuum*)

Pasture sage (*Artemisia frigida*)

Penstemon (*Penstemon* spp.)

Peppergrass (*Lepidium nitidum*)

Rock cress (*Arabis holboellii*)

Rosy pussytoes (*Antennaria rosea*)

Silky lupine (*Lupinus serecius*)

Stinkweed (*Thlaspi arvense*)

Thompson's paintbrush (*Castillega thompsonii*)

Thread-leaf fleabane (*Erigeron filifolius*)

Three-flowering avens (*Geum triflorum*)

Timber milkvetch (*Astragalus miser*)

White leaf phacelia (*Phacelia hastata*)

Yarrow (*Achillea millefolium*)

Yellow locoweed (*Oxytropis campestris*)

Shrubs and Trees

Big sagebrush (Artemisia tridentata)

Choke cherry (Prunus virginiana)

Douglas-fir (Pseudotsuga menziesii)

Douglas maple (Acer glabrum)

Engelmann spruce (Picea engelmannii)

Kinnikinnick (Arctostaphylos uva-ursi)

Lodgepole pine (Pinus contorta)

Low sagebrush (Artemisia arbuscula)

Mock orange (Philadelphus lewisii)

Mountain big sagebrush (Artemisia tridentata ssp. vaseyana)

Ponderosa pine (Pinus ponderosa)

Rabbitbrush (Chrysothamnus nauseosus)

Rose (Rosa nutkana)

Saskatoon (Amelanchier alnifolia)

Snow buckwheat (Eriogonum niveum)

Snowberry (Symphoricarpus albus)

Subalpine fir (Abies lasiocarpa)

Trembling aspen (Populus tremuloides)

Wild buckwheat (Eriogonum heracleoides)

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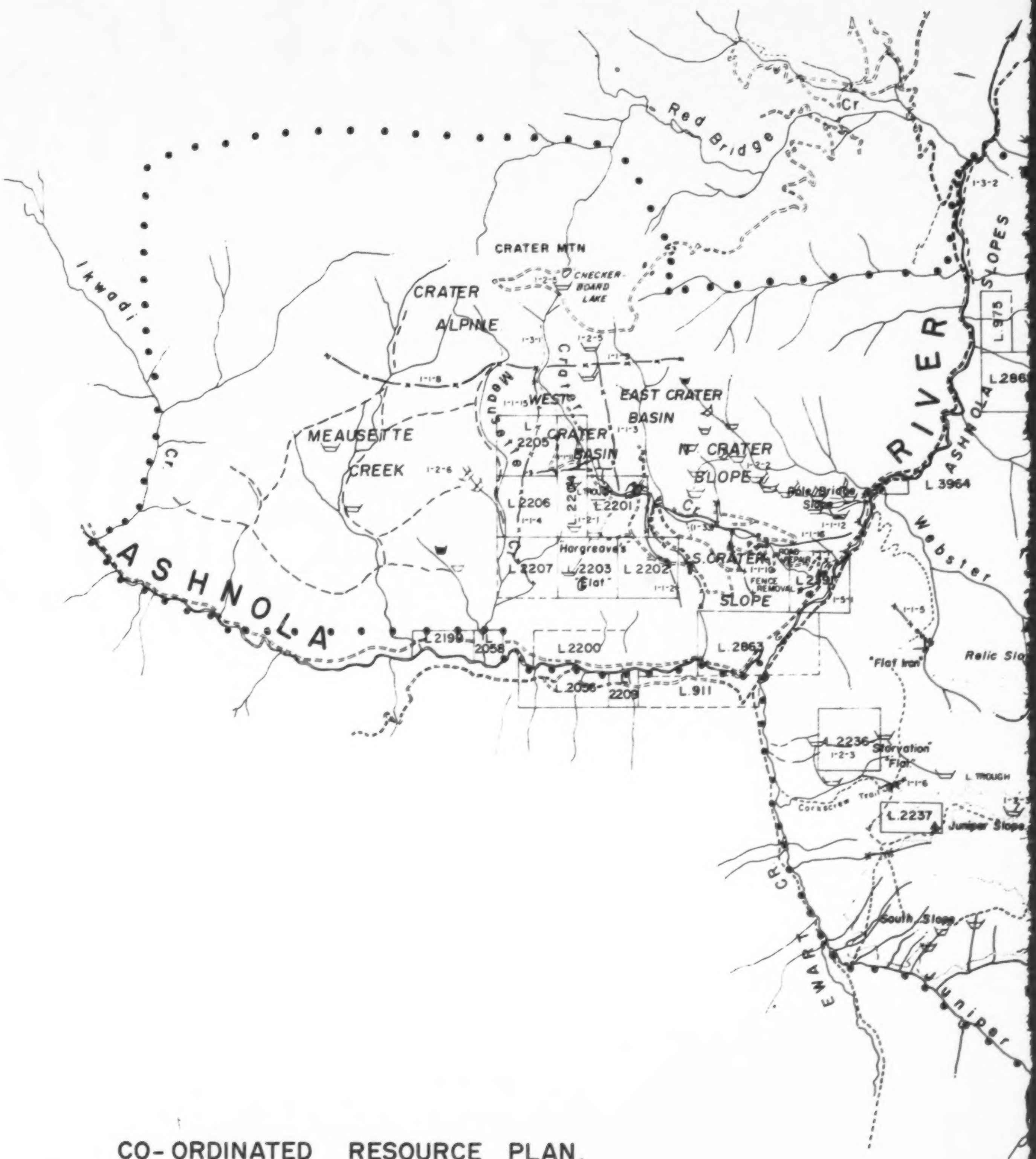
* Taxonomic nomenclature based upon Taylor and MacBryde (1977)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Ikwadi
CRATER MTN
CHECKER-BOARD LAKE
CRATER
ALPINE
Meausette
Crater
WEST CRATER BASIN
EAST CRATER BASIN
N. CRATER SLOPE
MEAUSETTE CREEK
L 2205
L 2206
L 2204
L 2201
L 2207
L 2203
L 2202
Hargreave's "Flat"
S. CRATER SLOPE
FENCE REMOVAL
Cr
Pole Bridge Slope
ASHNOLA
RIVER
ASHNOLA SLOPES
L 975
L 2869
L 3964
Webster
Relic Slo
"Flat Iron"
L 2199
L 2058
L 2200
L 2863
L 2056
2209
L 911
L 2236
Starvation "Flat"
L TROUGH
Corkscrew Trail
L 2237
Juniper Slope
South Slope
EWART CR
Juniper
1-3-2
1-2-5
1-3-1
1-1-8
1-1-15
1-1-3
1-2-6
1-2-2
1-1-4
1-2-1
1-1-12
1-1-16
1-1-10
1-5-1
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1-1-6

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CRATER MTN—JUNIPER CR.
1976

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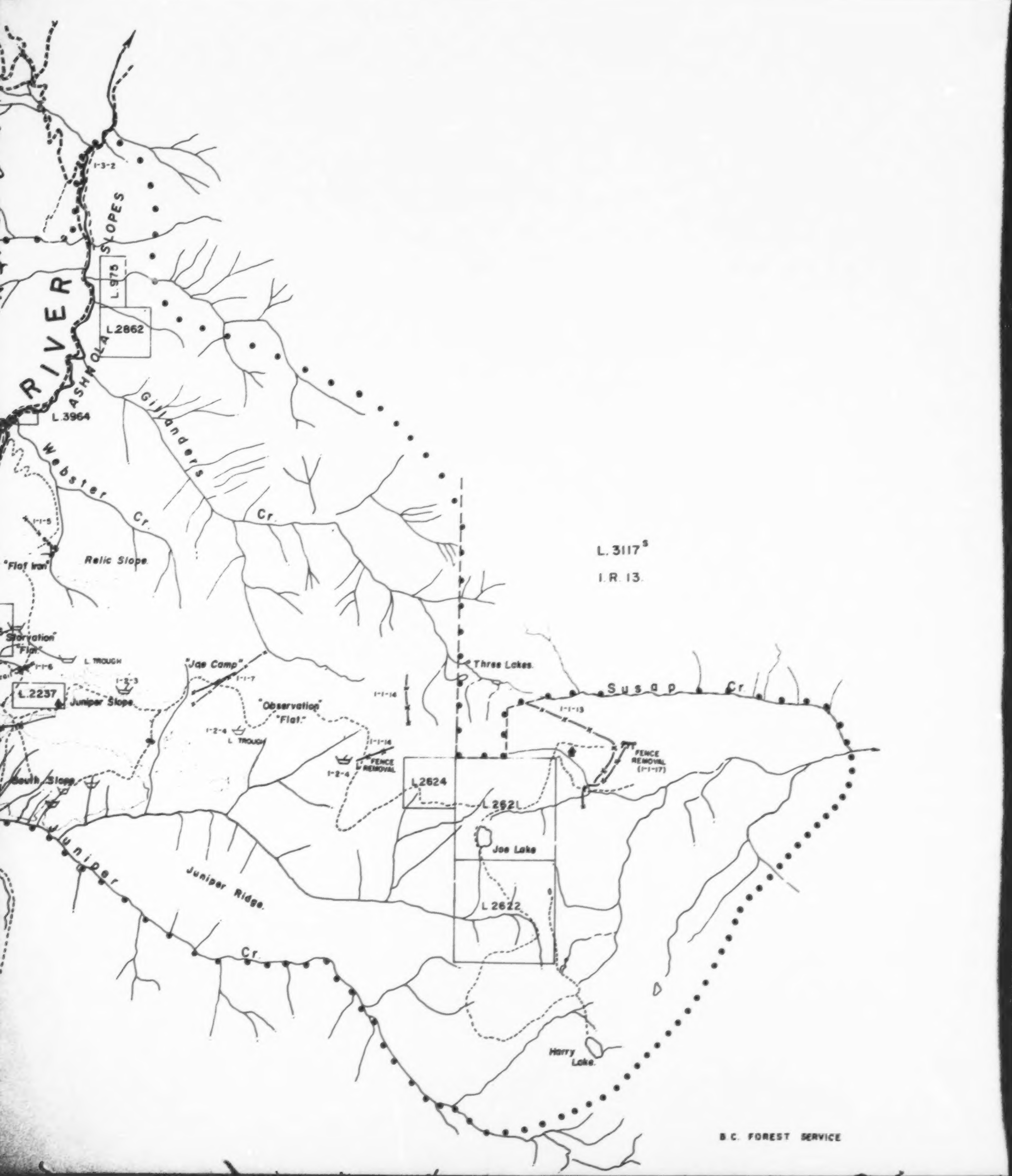
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1-1-5
"Flat Iron"
Relic Slope.
L. 3117S
I.R. 13.
"Starvation"
"Flat."
1-1-6
L. TROUGH
L.2237
Juniper Slope
1-2-3
"Joe Camp"
1-1-7
"Observation"
"Flat."
1-2-4
L. TROUGH
1-1-14
1-1-16
FENCE
REMOVAL
1-2-4
Three Lakes.
Susap
Cr.
1-1-13
FENCE
REMOVAL
(1-1-17)
L.2624
L.2621
Joe Lake
L.2622
South Slope
Juniper
Juniper Ridge.
Cr.
Harry
Lake.

B.C. FOREST SERVICE